37,40

1 Vol.

U.S. Department Of Energy

San Francisco Operations Office, Oakland, California 94612

Lawrence Livermore National Laboratory

University of California Livermore, California 94551

UCRL-AR-115640-94-4

LLNL Ground Water Project

90000 00986

1994 Annual Report

Technical Editors:

J. Hoffman*
P. McKereghan*
J. Macdonald*
B. Qualheim
R. Bainer
E. Folsom
M. Dresen*

Contributing Authors:

S. Bahowick
L. Berg*
K. Folks**
J. Hoffman*
G. Howard
M. Maley*
B. Mallon
P. McKereghan*
C. Noyes*
M. Ridley
E. Sorensen*
S. Shukla
T. Vogele*

*Weiss Associates, Emeryville, California
**Environmental Monitoring and Analysis Division

Environmental Protection Department

Environmental Restoration Division

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

UCRL-AR-115640-94-4

LLNL
Ground Water Project

1994 Annual Report

Technical Editors:

J. Hoffman*
P. McKereghan*
J. Macdonald*
B. Qualheim
R. Bainer
E. Folsom
M. Dresen*

Contributing Authors:

S. Bahowick
L. Berg*
K. Folks**
J. Hoffman*
G. Howard
M. Maley*
B. Mallon
P. McKereghan*
C. Noyes*
M. Ridley
E. Sorensen*
S. Shukla
T. Vogele*

*Weiss Associates, Emeryville, California
**Environmental Monitoring and Analysis Division

Contents

Appendices

List of Figures

List of Tables

Summary

1. The Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project produced three major Comprehensive Environmental Response, Compensation, and Liability Act documents in 1994: Remedial Design Report No. 3, issued March 1; Remedial Design Report No. 6 (RD6), issued November 30; and Draft Remedial Design Report No. 5, distributed December 1. Sixteen additional documents were produced in 1994, including Monthly Ground Water Project (GWP) Progress Reports; the March, June, and September 1994 GWP Quarterly Progress Reports; and the GWP 1993 Annual Report.

2. The Community Work Group met five times in 1994 to discuss topics, including RD6; the proposed Livermore Site Restoration Activities Priority List; the revised Remedial Action Implementation Plan schedule; comparison of ground water treatment technologies for the Trailer 5475 Area; the baseline risk assessment in the Remedial Investigation (Thorpe *et al.*, 1990); U.S. Department of Energy budget status; Arroyo Pipeline extension; and organizational issues.

3. Twelve source investigation boreholes were drilled in the W-501 and Building 191 Areas, and three boreholes were drilled in the Helipad Area. Fourteen of these boreholes were completed as piezometers.

4. The NUFT (Nonisothermal Unsaturated Flow and Transport) computer model was used to simulate a single-well soil vapor extraction system at Building 518. The NUFT model that simulates the movement of tritium in the vadose zone beneath the Building 292 tank leak is being enhanced by assigning values to areas where measured data are lacking.

5. We are continuing to build a three-dimensional (3-D) framework, consisting of hydrostratigraphic units, to characterize the subsurface beneath LLNL and optimize extraction well and piezometer locations. We evaluated a Ground Water Modeling System developed by the U.S. Department of Defense for building a 3-D ground water flow and transport model of the LLNL subsurface. We also developed several decision support tools and Graphical User Interfaces using Mosaic to aid data analysis and monitor remedial efforts.

6. Ground water from extraction well W-415 was treated at Treatment Facility A (TFA). In August 1994, we began extracting ground water from Arroyo Seco extraction wells W-109 and W-408. In September, TFA also began treating ground water from eight extraction wells south of TFA. By the end of 1994, the combined flow from W-415 and the additional TFA extraction wells was 175 gallons per minute. In November, a filter bed containing 1,500 lb of granular activated carbon was installed at Treatment Facility B (TFB) to decrease hydrogen peroxide concentrations and bring the effluent into compliance with fish toxicity standards. The extraction wells, extraction rates, and estimated volatile organic compound (VOC) mass removed in 1994 at TFA, TFB, Treatment Facility C (TFC) and Treatment Facility D (TFD) are summarized below.

Treatment Facility	Extraction wells	Extraction rate (gpm)	Estimated total VOC mass removed (kg)
TFA	W-415, W-518, W-520, W-521, W-522, W-601, W-602, W-603, W-609	50-175	5.6
TFB	W-357, W-704	22	2.7
TFC	W-701	15-30	1.2
TFD	W-351, W-906, W-907	10-15	0.3

Note:

gpm=gallons per minute.

kg=kilograms.

7. Design of the TFA North Pipeline and design of the TFB North Pipeline were completed this year. Construction of the TFA Arroyo Seco Pipeline and a pipeline in the ditch connecting TFC to Arroyo Las Positas was completed. Treatment Facility D construction was completed in July 1994 and activated in September 1994.

8. Hydraulic tests were conducted on well W-612 and the additional TFA extraction wells.

9. Two extraction wells and five piezometers were installed in the TFA Area. Four piezometers were installed in the TFB Area. Four extraction wells and one monitor well were installed in the TFC Area.

10. By the end of 1994, TFA, TFB, TFC and TFD were operational. To date, almost 124 million gal of ground water has been processed, removing almost 60 kg of VOCs.

11. Treatment Facility F continued to treat ground water from extraction wells GEW-808 and GEW-816, and vapor from wells GEW-808, GEW-816, and GSW-16. This year, 79 gal of liquid-equivalent gasoline was removed from the subsurface.

12. In January, a treatability test in the Trailer 5475 Area demonstrated the feasibility of separating VOCs from ground water containing tritium without a release of tritium to the environment, using a closed-loop air stripping system.

13. We conducted a field demonstration of a new instrument, the colloidal borescope designed by Oak Ridge National Laboratory. The borescope measures ground water movement within a borehole by recording the velocity and direction of movement of colloids suspended in the ground water column. Our impending purchase of a borescope will enable us to measure the velocity and velocity vectors in various wells during pump tests at both the Livermore Site and Site 300.

LLNL Ground Water Project

1994 Annual Report

Introduction

This report reviews the 1994 Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project (GWP) activities in five sections: Regulatory Compliance; Field Investigations; Data Analysis and Interpretation; Annual Summary of Remedial Action Program, including discussions of treatment facility activities; and Trends in Ground Water Analytical Results. The December 1994 Monthly GWP Progress Report (McConachie and Liddle, 1994) was issued as a separate document.

Figure 1 shows the locations of monitor wells, piezometers, extraction wells, and treatment facilities at the Livermore Site and vicinity as well as other areas referenced in this report. Beginning in this report, the prefixes of all wells (MW for monitor well, EW for extraction well, and P for piezometer) have been changed to W for simplicity. Well numbers will remain the same (e.g., MW-375 becomes W-375).

Appendices A through C present Well Construction and Closure Data, Results of Hydraulic Tests, and the 1994 Ground Water Sampling Schedule, respectively. Ground water volatile organic compound (VOC) analyses, water level elevations, and the Treatment Facility F (TFF) area ground water VOC and fuel hydrocarbon (FHC) analyses are available on request.

Appendix D presents an update of the Drainage Retention Basin (DRB) Monitoring Results conducted by the LLNL Environmental Monitoring and Analysis Division (EMAD) for September 1994 through December 1994 as requested by the California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region.

Regulatory Compliance

In 1994, the U.S. Department of Energy (DOE)/LLNL submitted three Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documents for the Livermore Site. In addition, DOE/LLNL produced 16 other documents and conducted community activities as discussed below.

CERCLA Documents

The final version of Remedial Design Report No. 3 (RD3) for Treatment Facilities C (TFC) and F (Berg *et al.*, 1994a) was issued on March 1, 1994, according to the revised schedule presented in the Remedial Action Implementation Plan (RAIP) (Dresen *et al.*, 1993). With regulatory and community concurrence, the RAIP schedule was revised on July 20, 1994, to add Remedial Design Report No. 6 (RD6) for the Building 518 vadose zone, and change the issue dates for Remedial Design Reports Nos. 4 and 5 (RD4 and RD5). In conjunction with the revised RAIP schedule, a consensus statement was signed by the LLNL Livermore Site

Remedial Program Managers that established cleanup priorities. RD6 for the Building 518 Vapor Treatment Facility (Berg *et al.*, 1994b) was issued on schedule on November 30, 1994. The draft version of RD5 for Treatment Facilities G-1 and G-2 (Berg *et al.*, 1994c) was distributed for review on schedule to the regulatory agencies and the community on December 1, 1994.

Other Documents

In 1994, DOE/LLNL also issued the following reports:

- The January through December 1994 Monthly GWP Progress Reports.
- The March, June, and September 1994 Quarterly GWP Progress Reports (Macdonald *et al.*, 1994; Hoffman *et al.*, 1994b; Hoffman *et al.*, 1994c, respectively).
- The LLNL 1993 GWP Annual Report (Hoffman *et al.*, 1994a).

As agreed to with the regulatory agencies in December 1994, reporting requirements were modified to reduce the scope of the GWP Annual Report, and to eliminate the Quarterly GWP Progress Reports.

Community Relations

The Community Work Group (CWG) met five times in 1994 to discuss topics including: RD6; the proposed Livermore Site Restoration Activities Priority List; the revised RAIP schedule; comparison of ground water treatment technologies for the Trailer 5475 Area; the baseline risk assessment in the Remedial Investigation report (Thorpe *et al.*, 1990); DOE budget status; the Arroyo Pipeline extension; and organizational issues (e.g., CWG operations and the Mission Statement).

Other community relations activities in 1994 included meeting periodically with a local interest group and its technical advisors; distributing the *Environmental Community Letter;* maintaining the Information Repositories and the Administrative Record; conducting tours of the site environmental activities; and staffing a telephone information line for public and news media inquiries. In November, a ribbon-cutting event marked the activation of Treatment Facility D (TFD). The event was attended by CWG representatives, a representative from Congressman Bill Baker's office, and DOE/LLNL officials and staff.

Field Investigations

Water Sampling

In 1994, the GWP collected 856 ground water samples from 279 wells. Of the wells sampled, 13 are Alameda County Flood Control and Water Conservation District, Zone 7, or domestic wells. The samples were analyzed for VOCs, FHCs, metals, tritium and gamma-emitting radionuclides, or a selection of analyses depending on the compounds of concern.

Summaries and results of ongoing monitoring are discussed in the 1994 LLNL GWP Quarterly Progress Reports.

The ground water sampling frequencies are updated quarterly by an algorithm that evaluates trends in contaminant levels in each well over an 18-month period. The main features of the algorithm that determine the sampling frequencies are based on the following criteria:

- Wells exhibiting little change (<10 ppb per year) are sampled annually.
- Wells exhibiting moderate change (≥ 10 ppb but < 30 ppb per year) are sampled semiannually.
- Wells showing large change (≥ 30 ppb) are sampled quarterly.
- Wells with less than 18 months of analytical history will be sampled quarterly for the first 18 months, then the algorithm logic will determine the sampling frequency.

Wells located at the leading edge of VOC plumes will always remain on a quarterly sampling schedule. Summaries and results of ongoing monitoring were discussed in the 1994 LLNL GWP Quarterly Progress Reports. The sampling schedule for 1995 is presented in Appendix C of this report.

Source Investigations

This year we continued our source investigations to further characterize sediment and ground water contamination. Twelve boreholes were drilled in the W-501 and Building 191 Areas, and three boreholes were drilled in the Helipad Area (Fig. 1). Results of these investigations will be presented in future GWP reports after all chemical data for each area investigated are received and interpreted. Details of the 1994 source investigation activities are briefly summarized below.

- During the second quarter of 1994, five boreholes were drilled in the W-501 Area to follow up initial source investigation drilling conducted in 1992 (Fig. 1). Five boreholes were also drilled north of Westgate Drive in the Building 191 Area to investigate the source of the perchloroethylene (PCE) in monitor well W-454 (Fig. 1). All of these boreholes were completed as piezometers screened in the first water-bearing zone, approximately 40 to 70 ft below ground surface. Additional information is presented in the June 1994 GWP Quarterly Progress Report (Hoffman, 1994b).
- In the fourth quarter of 1994, we drilled and installed piezometer SIP-501-201 in the W-501 Area and piezometer SIP-191-101 in the Building 191 Area (Fig. 1). These piezometers are screened in the first water-bearing zone, approximately 40 to 70 ft below ground surface.
- Also in the fourth quarter of 1994, we drilled three boreholes in the Helipad Area (Fig. 1). Two of the boreholes were completed as piezometers SIP-HPA-102 and SIP-HPA-103, screened in the first water-bearing zone between depths of approximately 67 to 72 ft. Borehole SIB-HPA-101 was drilled and sampled to a depth of about 35 ft and then grouted to the surface.

- Samples collected from approximately 5- and 10-ft depths, and each consecutive 10 ft interval to the water table in all the boreholes, were analyzed for VOCs and tritium. An additional sample collected from approximately 5 ft in each borehole was also collected for Soluble Threshold Limit Concentration metals analyses. Ground water samples bailed from the open boreholes drilled to the water table were analyzed for VOCs, tritium, and dissolved drinking water metals.
- All source investigation piezometers installed in 1994 were developed using a combination of air-lift and/or surge block, and bailing.

Data Analysis and Interpretation

Flow and Transport Modeling

Both unsaturated and saturated zone modeling were conducted during 1994 in support of regulatory documents and remedial design, and to assist in further understanding the Livermore Site subsurface.

Unsaturated Zone Modeling

During 1994, computer simulations of a single well Soil Vapor Extraction (SVE) system at Building 518 were finalized. The simulations were conducted using the LLNL computer code Nonisothermal Unsaturated Flow and Transport (NUFT). Both the conceptual model and calibration of the NUFT SVE model were based on treatability tests performed in September 1993 through January 1994.

In September 1994, the methodology and results of the Building 518 SVE simulation were presented to representatives of the regulatory agencies. This presentation was conducted in response to regulatory comments and questions on Draft RD6 (Berg *et al.*, 1994b) regarding the NUFT model and its application for remediation design. A report describing the Building 518 vadose zone modeling will be issued in 1995.

During 1994, we continued collecting data to evaluate the tritium distribution in the Building 292 Area subsurface. Tritium concentrations in ground water bailed from piezometer UP-292-001 fluctuated between about 7,000 and 37,000 picocuries per liter (pCi/L) during 1994. The tritium trend followed the ground water elevation trend throughout the year (Fig. 2). Piezometer UP-292-001 is the only well that has recorded tritium in ground water above the 20,000 pCi/L drinking water standard in the Building 292 Area.

All the data collected in the Building 292 Area thus far have been incorporated into a computer model to provide estimates of tritiated moisture movement within the subsurface. The model has been verified with experimental results, and work is in progress to assign values to locations where there are no measured data.

Saturated Zone Modeling

We are continuing to build a three-dimensional (3-D) framework to characterize the LLNL subsurface. Using the extensive GWP database and previous work conducted at the site, we are defining a set of subsurface units, termed hydrostratigraphic units, to increase our understanding of the contaminant transport pathways. This work is currently being conducted to optimize extraction well and piezometer locations to meet requirements of the Record of Decision (DOE, 1992) and Remedial Design reports. In the upcoming year, these data will be incorporated into a 3-D numerical model to further aid in long-term wellfield management and compliance monitoring.

During 1994, we evaluated a Ground Water Modeling System (GMS) developed by the U.S. Department of Defense for building a 3-D ground water flow and transport model of the LLNL subsurface. Though still hampered by some coding errors, the model proved to be quite useful for creating input files for a 3-D MODFLOW model. Additional code has been written to create 3-D CFEST input files with GMS. In addition, various forward and inverse computer codes were compared using generic sample problems as part of a Laboratory Directed/Research and Development project. MODINV, an inverse ground water flow model based on the popular MODFLOW code, was compared to PDEASE, a new generic solver for partial differential equations developed at LLNL. GMS was used to visualize and evaluate results from MODINV.

To enhance information transfer within the modeling project team and inform other Environmental Restoration Division (ERD) staff, representative modeling results were incorporated into World Wide Web Home Pages accessible through the Internet using the Mosaic software. The home pages are updated as the project progresses and new data are available.

We also developed several decision support tools and Graphical User Interfaces using Mosaic to aid data analysis and monitor remedial efforts at LLNL. Specifically, ERD staff can now easily build database queries, create time series graphs and plan-view contour maps, and view geologic well logs from their workstations.

Annual Summary of Remedial Action Program

Treatment Facility A

Treatment Facility A (TFA) is located in the southwestern part of LLNL near Vasco Road (Fig. 1). TFA processes ground water using a combination of ultraviolet light/hydrogen peroxide (UV/H_2O_2) treatment and air-stripping technologies. During 1994, we continued to extract ground water from W-415 at an average flow rate of about 50 gallons per minute (gpm). Pumping at W-415 was halted during April and May 1994 to perform the following tasks:

- Start-up testing for extraction wells located immediately south of TFA.
- Colloidal borescope testing in W-415.
- Multilevel sampler installation in W-415.
- Pump installation in W-415.

In September, following modification of the pipeline that connects extraction wells south of TFA to TFA, we began treating ground water from extraction wells W-520, W-602, and W-522 (Fig. 1) (Hoffman *et al.*, 1994c). In December, TFA also began processing ground water from five additional extraction wells south of TFA (W-609, W-603, W-518, W-521, and W-601). By year's end, TFA was processing about 75 gpm of ground water from the wells south of TFA and about 50 gpm from W-415.

During the third quarter of 1994, we also completed construction of the Arroyo Seco Pipeline. In August 1994, we began extracting ground water from Arroyo Seco extraction wells W-109 and W-408 (Fig. 1). In October 1994, we began continuously pumping these wells. Flow rates from these two wells averaged about 50 gpm during the fourth quarter of 1994. By the end of 1994, the combined flow from all extraction wells connected to TFA was 175 gpm. Previously, the average flow rate through TFA was about 50 gpm.

During 1994, more than 23 million gal of ground water containing VOCs was processed at TFA (Table 1). All treated ground water was discharged to the Recharge Basin, located about 2,000 ft southeast of TFA (Fig. 1). Based on monthly influent concentrations and flow data, we estimate that about 2.5 kilograms (kg) of VOC mass were removed from ground water at TFA during the fourth quarter of 1994. The total VOC mass removed during 1994 was about 5.6 kg (Table 1). Since system startup in 1989, TFA has processed nearly 98 million gal of ground water and removed about 46 kg of VOC mass from the subsurface (Table 2).

Table 1. Summary of 1994 ground water VOC remediation.

Treatment facility	Volume of ground water treated (Mgal)	Estimated total VOC mass removed (kg)
TFA	23	5.6
TFB	8.4	2.7
TFC	2.6	1.2
TFD	0.09	0.3
Totals	34	10

Table 2. Summary of cumulative ground water VOC remediation.

Treatment facility	Total volume of ground water treated (Mgal)	Estimated total VOC mass removed (kg)
TFA	98	46
TFB	23	9
TFC	2.8	1.2
TFD	0.09	0.3
Totals	124	56

During 1995, we plan to connect extraction wells W-904, W-903, and W-457 to the Arroyo Pipeline to aid in achieving hydraulic control of the offsite plume. During 1994, we completed the design of the TFA North Pipeline. We plan to construct the TFA North Pipeline to extraction wells in the W-1004 area (Fig. 1) in 1995.

Field Activities

During 1994, TFA North Pipeline extraction wells W-1004 and W-1009 were installed. In addition, five piezometers were installed near the Arroyo Pipeline and south of TFA (W-1002, W-1003, W-1005, W-1006, and W-1007) (Fig. 1). Details of these new extraction wells and piezometers are presented in Appendix A.

Hydraulic Tests

Long-term hydraulic tests were conducted during 1994 on well W-612, the extraction wells south of TFA, and the Arroyo Pipeline extraction wells. The W-612 test is described in the September 1994 GWP Quarterly Progress Report (Hoffman *et al.*, 1994c), and the results are presented in Appendix B of this report. The other two tests are briefly described below.

In September and October 1994, a four-week-long hydraulic test was conducted on DSA extraction wells W-520, W-602, and W-522 to determine the maximum sustainable flow rates for each well. Thirty-six surrounding wells in the TFA Area were monitored to determine the hydraulic influence of each well.

In mid-October, a hydraulic test was conducted on Arroyo Pipeline wells W-109 and W-408 to establish their maximum sustainable flow rates. Twenty-nine wells in the TFA area were monitored to evaluate the extent of hydraulic influence. Based on the test, we plan to upgrade the pump in W-109 to increase the pumping rate from 20 to about 30 gpm. The degree of hydraulic communication between wells, was used to refine our understanding of the TFA Area hydrostratigraphy. A report discussing the hydraulic test results and summarizing the Livermore Site hydrostratigraphy is planned following completion of all Remedial Design reports.

Treatment Facility B

Treatment Facility B (TFB) is located along Vasco Road just north of Mesquite Way (Fig.1). Similar to TFA, TFB processes ground water using a combination of UV/H_2O_2 treatment and air-stripping technologies. In 1994, we increased the amount of H_2O_2 added to the UV chamber to reduce hexavalent chromium to trivalent chromium, and reduce effluent hexavalent chromium concentrations below the TFB discharge limit of 10 parts per billion (ppb). However, the higher concentration of H_2O_2 in the effluent water apparently resulted in lower than allowable fish bioassay survival rates. In November 1994, a filter bed containing 1,500 lb of granular activated carbon was installed following the UV chamber. Test results of bioassay samples collected on November 30 and December 7, 1994, indicated that H_2O_2 concentrations decreased, and the fish survival rates were 100%.

During 1994, about 8.4 million gal of ground water extracted from wells W-357 and W-704 was treated at TFB (Table 1). The average combined total flow rate from these wells was about 22 gpm. In 1994, all the ground water treated at TFB was discharged to the north-flowing drainage ditch along Vasco Road.

Based on monthly influent concentrations and flow data, we estimate that about 0.5 kg of VOC mass were removed from ground water at TFB during the fourth quarter of 1994. The total VOC mass removed during 1994 was about 2.7 kg (Table 1). Since system startup in 1991, TFB has processed more than 23 million gal of ground water and removed about 9 kg of VOC mass from the subsurface (Table 2).

During 1994, we completed the design of the TFB North Pipeline. This pipeline will convey water from extraction wells W-610, W-620, W-621, and W-655 to TFB (Fig. 1). Construction of the pipeline is expected to be completed by mid-1995.

Field Activities

To increase the infiltration of treated ground water discharged to the drainage ditch along Vasco Road, the surface of the ditch was dredged in the Fall of 1994.

Piezometers W-1010, W-1011, W-1012, and W-1013 were installed in the TFB Area during 1994 to monitor the hydraulic effects when pumping the TFB North Pipeline extraction wells begins (Fig. 1) (Appendix A).

Treatment Facility C

TFC is located in the northwest quadrant of LLNL (Fig. 1) and employs air-stripping and ion-exchange technologies to process ground water. During the first half of 1994, TFC operated during business hours only (i.e., 8 a.m. to 5 p.m., Monday through Friday). During this time, we were able to pump extraction well W-701 at a higher rate (about 30 gpm), because ground water levels near the well recovered while the facility was not operating. On June 2, 1994, we began operating TFC continuously during the work week (i.e., 24 hr a day, Monday through Friday). As a result, the sustainable yield from extraction well W-701 decreased to about 15 gpm. On December 9, 1994, we began full-time operation of TFC (i.e., 24 hr a day, 7 days a week). The TFC North Pipeline design is scheduled for completion in early 1995.

In 1994, TFC processed about 2.6 million gal of ground water containing about 1.2 kg of VOCs (Table 1). Since system startup in October 1993, about 2.8 million gal of ground water containing 1.2 kg of VOC mass have been removed from the subsurface (Table 2).

Field Activities

Prior to July 8, 1994, ground water treated at TFC was discharged to a north-flowing drainage ditch near TFC. In July 1994, a pipeline was installed in the ditch to convey treated water from TFC north to Arroyo Las Positas and prevent infiltration of treated water into underlying ground water that may contain VOCs and potentially spreading and/or diluting the plume.

Wells W-1014, W-1015, W-1101, W-1102, and W-1103 were installed in the TFC Area during 1994 (Appendix A). Wells W-1015, W-1101, W-1102, and W-1103 are tentatively scheduled to pump ground water to TFC in 1996 via the TFC North Pipeline. Because these wells would replace the wells discussed in Remedial Design Report No. 2 (Berg *et al.,* 1993), they are being evaluated to ensure that they will hydraulically capture the VOC plume in the northwest portion of LLNL. Two additional extraction wells are also planned for the TFC Area in early 1995.

As discussed in the Source Investigations section of this report, 12 piezometers were installed in the TFC area to further characterize sediment and ground water contamination.

Treatment Facility D

TFD is located in the northeast quadrant of LLNL (Fig. 1) and uses air-stripping and ion-exchange technologies to process ground water. Construction of TFD began on February 28, 1994, and was completed on July 13, 1994. TFD was activated and operation began on September 15, 1994, by pumping and treating ground water from well W-906 (Fig. 1). The treated water discharge to the DRB began September 29, 1994, ahead of schedule.

In October 1994, we began extracting ground water from wells W-351, W-906, and W-907. The average total flow rate from these wells is about 15 gpm. In November 1994, we discontinued pumping W-907 because ground water from this well contains nickel in concentrations greater than the 7 ppb TFD discharge limit. As a result, the average total flow rate from W-351 and W-906 is about 10 gpm. In 1995, we plan to resume ground water extraction from W-907 and begin discharging treated ground water directly to Arroyo Las Positas via an underground drainage pipeline.

During 1994, we processed about 91,000 gal of ground water removing an estimated 0.3 kg of VOC mass (Table 1). All the treated water was discharged to the DRB.

By the end of 1994, TFA, TFB, TFC and TFD were operational. Figure 3 shows the total VOC mass removed at each of the treatment facilities since startup, and the cumulative total VOC mass removed. To date, almost 124 million gal of ground water has been processed, removing almost 60 kg of VOC mass.

Field Activities

As discussed in the Source Investigations section of this report, three source investigation boreholes were drilled in the Helipad Area east of TFD to further characterize the VOCs in this area. Two of these boreholes were completed as piezometers and screened in the first water-bearing zone.

Treatment Facility E

No work was conducted this year for Treatment Facility E. As agreed to with the regulatory agencies, future activities have been delayed to be consistent with expected funding and project priorities.

Treatment Facility F

During 1994, we continued operating TFF, located in the southern part of the Livermore Site (Fig. 1), during business hours only.

As shown in Table 3, TFF treated approximately 4 million gal of ground water from extraction wells GEW-808 and GEW-816 containing a volume-weighted average FHC concentration of about 2,900 ppb. This is equivalent to about 15 gal liquid-equivalent of gasoline removed. In addition, TFF extracted about 8 million cubic feet (ft^3) of vapor containing a volume-weighted FHC concentration of about 209 parts per million by volume (ppmv), for about 64 gal liquid-equivalent of gasoline removed. Therefore, the total liquid-equivalent of gasoline removed from the TFF subsurface during 1994 was about 79 gal (Table 3). The TFF gasoline removal rate has declined steadily throughout the year as recoverable gasoline remaining in the area is reduced.

Ground water and vapor extracted from the TFF area subsurface continue to have elevated temperatures due to the Dynamic Underground Stripping Project conducted at the site in early 1993. In December 1994, extracted ground water temperatures averaged about 100°F and extracted vapor temperatures averaged about 120°F, even though subsurface temperatures at the site currently range from about 130° to 170°F.

Table 3. TFF gasoline removal, 1994 .

	Hydrocarbon Concentration[a]		Volumes pumped		Gasoline removal (gal)[b]		
Month	Water (ppb)	Vapor (ppmv)	Water (gal)	Vapor (ft^3)	Water	Vapor	Totals
January	6,400	1,172	193,000	430,000	1.6	18.8	20
February	5,200	724	265,000	400,000	1.8	10.8	13
March	4,200	592	401,000	530,000	2.2	11.7	14
April	3,200	320	380,000	645,000	1.6	7.7	9
May	3,500	168	87,000	176,000	0.4	1.1	2
June	2,200	113	383,000	785,000	1.1	3.3	4
July	2,100	99	400,000	840,000	1.1	3.1	4
August	2,300	66	462,000	1,020,000	1.4	2.5	4
September	2,300	34	433,000	1,020,000	1.3	1.3	3
October	2,200	36	280,000	665,000	0.8	0.9	2
November	2,200	29	276,000	730,000	0.8	0.8	2
December	1,600	49	387,000	924,000	0.8	1.7	3
Totals	2,900	209	3,950,000	8,170,000	15	64	79

[a] Flow-weighted concentration averages.

[b] Liquid-equivalent gallons of gasoline.

Trailer 5475 Treatment Facility

The Trailer 5475 (T5475) Area is located in the southeast quadrant of the Livermore Site (Fig. 1). As agreed to with the regulatory agencies, design and construction activities for the T5475 Treatment Facility have been postponed from FY 1997 to FY 1998 and FY1999 to be consistent with expected funding and project priorities. However, hydrostratigraphic analyses and extraction well placement optimization continue in preparation for submittal of RD4 in FY 1997.

Treatability Test

In January 1994, a treatability test was conducted to demonstrate the feasibility of separating VOCs from ground water using a closed-loop air stripping system and to aid in the design of the T5475 Treatment Facility. A description and the results of the treatability study are presented in the September 1994 GWP Quarterly Progress Report (Hoffman *et al.*, 1994c).

Building 518 Vapor Treatment Facility

As discussed in the Regulatory Compliance section of this report, RD6 (Berg *et al.*, 1994b) was issued to the regulators and the community on November 30, 1994.

The design of the vapor extraction system (VES) concrete pad was completed this year (1994). Early next year, LLNL's Plant Engineering will finalize the details of the VES power service, and the VES design specifications will be completed. The VES is scheduled to begin operation September 29, 1995.

Trends in Ground Water Analytical Results

Discussed below are notable results of VOC analyses of ground water from 130 monitoring locations received between October, 1994, and December 31, 1994.

1. The trichloroethylene (TCE) concentration in W-11 has gradually decreased. W-11 is located approximately 300 yd southeast of TFF on DOE property administered by Sandia National Laboratories (Fig. 1), and is screened from 136 to 141 ft and from 177 to 187 ft. In April 1983, less than 5 ppb TCE was reported in the initial analysis. Since that time, the TCE concentration increased to 160 ppb in October 1991, but has since steadily decreased to 39 ppb as of October 1994.

2. The TCE concentration in W-369 has increased. W-369 is located northwest of the DRB (Fig. 1) and is screened from 107 to 113 ft. In May 1987, less than 1 ppb TCE was reported in the initial analysis. However, the TCE concentration has increased from 0.7 ppb in August 1992 to 53 ppb as of October 1994.

3. The Freon 11 concentration in W-486 has increased. W-486 is located in the northern portion of the site (Fig. 1) and is screened from 100 to 108 ft. In March 1988, less than 0.5 ppb Freon 11 was reported in the initial analysis. Recently, the Freon 11 concentration increased from less than 0.5 ppb in August 1993 to 28 ppb as of August 1994.

Acknowledgments

The LLNL Ground Water Project is supported by a number of people who contribute significantly to the project. The editors and authors are pleased to recognize their efforts.

W. McConachie, LLNL Environmental Restoration Division Leader, provides overall direction and technical guidance.

A. Copeland, LLNL Environmental Restoration Deputy Division Leader, provides quality assurance and technical guidance.

J. Ziagos, LLNL Livermore Site Section Leader, provides overall guidance and directs the activities.

D. Bishop of LLNL directs and coordinates chemistry and sediment laboratory work.

T. Ottesen of LLNL maintains the database, provides chemical data as needed by project personnel and camera ready presentation of water level, and analytical data for appendices.

J. Tulk, K. Rauhut, and K. Graham of LLNL provide legal support.

J. Iovenitti of Weiss Associates works on vadose zone investigations.

R. Devany of Weiss Associates provides hydrogeologic oversight and aids in well design.

R. Gelinas of LLNL and Eric Nichols of Weiss Associates oversee ground water and vadose zone modeling.

A. Tompson of LLNL works on ground water and vadose zone modeling.

V. Johnson of LLNL oversees statistical and optimization analyses and coordinates computer resources.

T. Canales and P. Mikes of LLNL provide computer programming support.

K. Fitzgerald and R. Quakenbush of Waltrip & Associates coordinate computer resources.

M. Jovanovich of LLNL works on ground water and sediment chemistry investigations.

P. Anderson and S. Kawaguchi of LLNL maintain Treatment Facilities A and B, and provide technical support.

B. Johnson and D. White of LLNL assist with activities at Treatment Facility F and provide technical support.

R. Attebery assists in the ground water sampling.

G. Duarte, L. Kita, and P. Lyra of LLNL coordinate field activities.

H. Van Noy of LLNL maintains Treatment Facility C and provides technical support.

D. Jenkins of Soil Exploration Services operates the auger drill rig.

P. Ries of PC Exploration operates the mud-rotary drill rig.

Scott Nelson and Erik Nielsen of Weiss Associates supervise drilling, monitor well installation, well development, and borehole logging.

J. Chiu of Weiss Associates performs well development, initial sampling, hydraulic tests, measures ground water levels, and provides preliminary interpretation of hydraulic data.

A. Ballard of Bendix/TID prepares the graphics.

H. Sherman of LLNL/TID provides editorial support.

N. Prentice of LLNL, L. Cohan, L. daRosa, and L. Rose-Webb of KMI provide clerical support.

California Laboratory Services, GTEL Environmental Laboratories, and IT Analytical provide analytical chemistry services to the project.

References

Berg, L. L., M. D. Dresen, E. N. Folsom, J. K. Macdonald, R. O. Devany, and J. P. Ziagos (Eds.) (1993), *Remedial Design Report No. 2 for Treatment Facilities C and F, Lawrence Livermore National Laboratory, Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-112814).

Berg, L. L., M. D. Dresen, E. N. Folsom, J. K. Macdonald, R. O. Devany, R. W. Bainer, R. G. Blake, and J. P. Ziagos (Eds.) (1994a), *Remedial Design Report No. 3 for Treatment Facilities D and E, Lawrence Livermore National Laboratory, Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-113880).

Berg, L. L., M. D. Dresen, E. N. Folsom, R. W. Bainer, R. J. Gelinas, E. M. Nichols, D. J. Bishop, and J. P. Ziagos (Eds.) (1994b), *Remedial Design Report No. 6 for the Building 518 Vapor Treatment Facility, Lawrence Livermore National Laboratory, Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-115997).

Berg, L. L., M. D. Dresen, R. W. Bainer, E. N. Folsom, and J. P. Ziagos (Eds.) (1994c), *Remedial Design Report No. 5 for Treatment Facilities G-1 and G-2, Lawrence Livermore National Laboratory, Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-116583 dr).

Dresen, M. D., J. P. Ziagos, A. J. Boegel, and E. M. Nichols (Eds.) (1993), *Remedial Action Implementation Plan for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-110532)(Table 5 revised February 25, 1993; page 43 revised September 2, 1993; Table 5 revised July 20, 1994).

Hoffman, J., P. McKereghan, B. Qualheim, R. Bainer, E. Folsom, M. Dresen, and J. Ziagos (Eds.) (1994a), *LLNL Ground Water Project 1993 Annual Report*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-115640-93-4).

Hoffman, J., M. Dresen, R. Bainer, E. Folsom, B. Qualheim, and J. Ziagos (Eds.) (1994b), *LLNL Ground Water Project Quarterly Progress Report, June 1994*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-115640-94-2).

Hoffman, J., M. Dresen, R. Bainer, E. Folsom, B. Qualheim, and J. Ziagos (Eds.) (1994c), *LLNL Ground Water Project Quarterly Progress Report, September 1994,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-115640-94-3).

Macdonald, J., M. Dresen, R. Bainer, E. Folsom, B. Qualheim, and J. Ziagos (Eds.) (1994), *LLNL Ground Water Project Quarterly Progress Report, March 1994,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-115640-94-1).

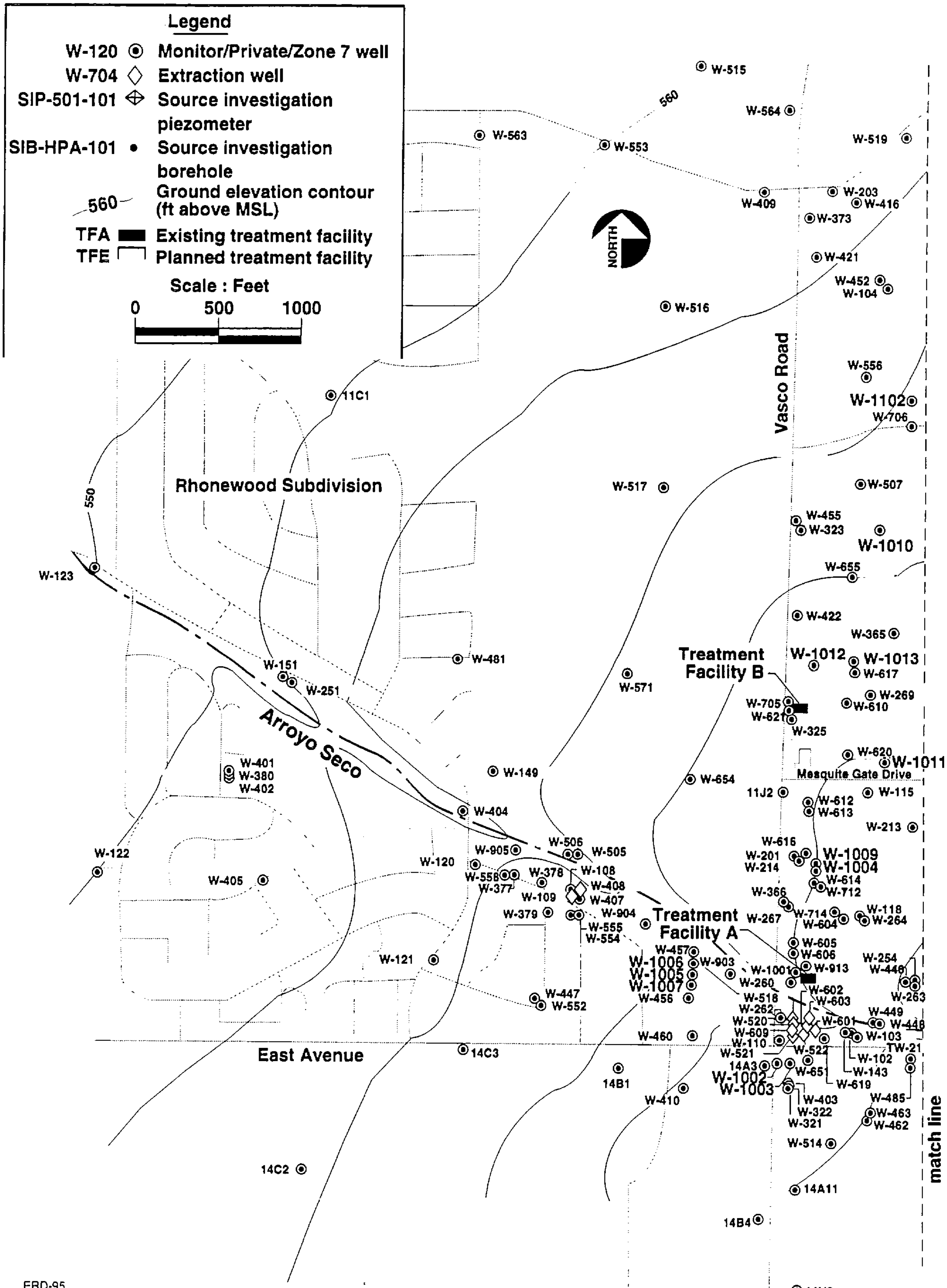
McConachie, W. A., and R. Liddle (1994), Letter report: Lawrence Livermore National Laboratory, Livermore Site, Ground Water Project Monthly Progress Report, December 1994.

Thorpe, R. K., W. F. Isherwood, M. D. Dresen, and C. P. Webster-Scholten (Eds.) (1990), *CERCLA Remedial Investigation Report for the LLNL Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10299).

U.S. Department of Energy (DOE) (1992), *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-109105).

Figures

This page was left blank so the following table could be shown on facing pages.



ERD-95
2/95

Figure 1. Locations of Livermore Site monitor wells, piezometers, extraction wells, and treatment facilities, December 1994.

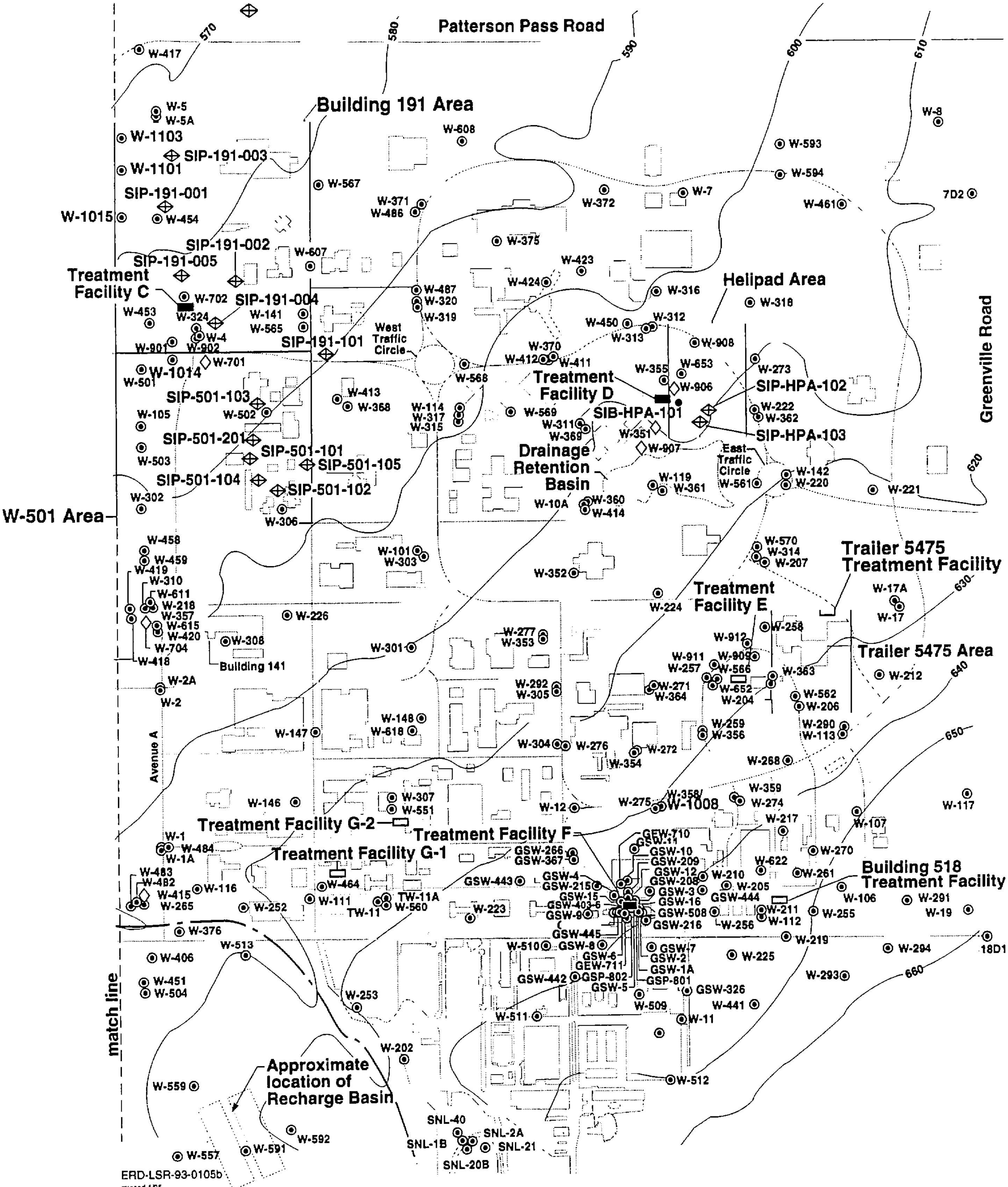


Figure 1 (continued).

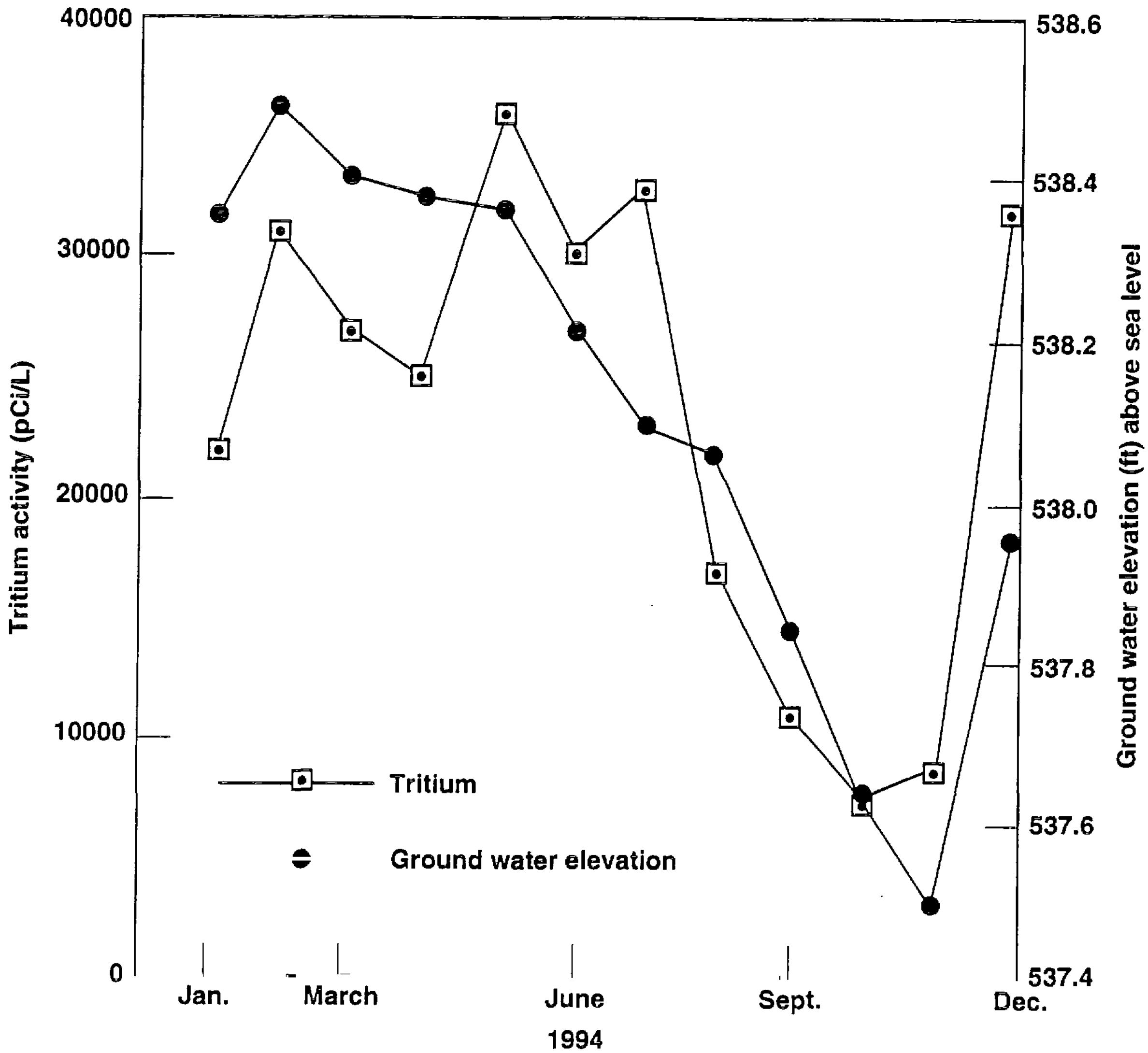


Figure 2. 1994 tritium activities and ground water elevations in piezometer UP-292-001, Building 292 Area.

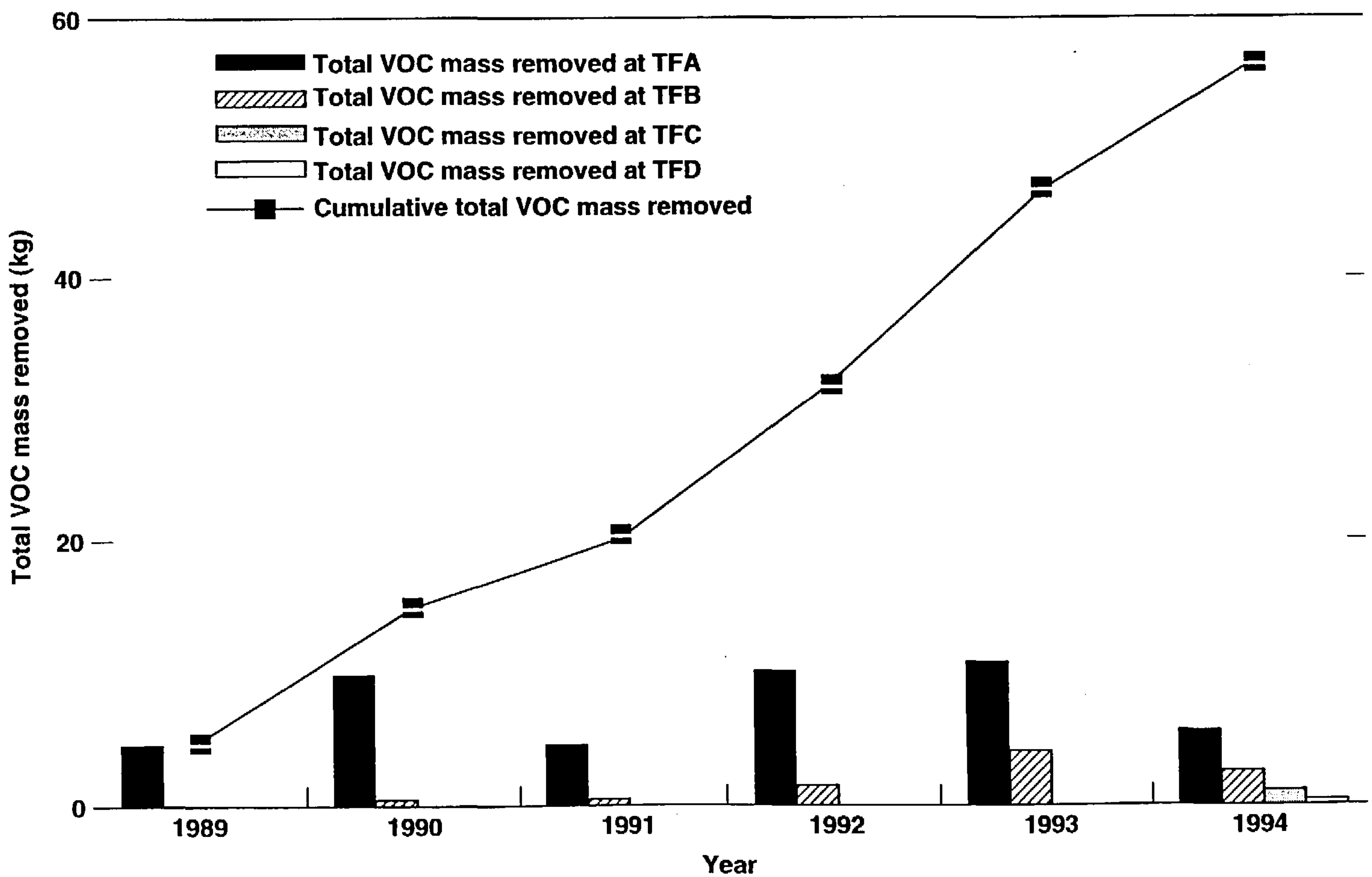


Figure 3. LLNL Treatment Facilities Performance Summary

Appendix A

Well Construction and Closure Data

Table A-1. Well construction data, Lawrence Livermore National Laboratory and vicinity, Livermore, California.

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
MONITOR WELLS						
W-1	21-Oct-80	122.5	116.0	95-100	First	NA
W-1A	12-Apr-84	180.0	156.0	145-156	Second	NA
W-2	29-Aug-80	102.5	101.0	86-101	First	NA
W-2A	02-Apr-84	185.0	164.0	150-164	Third and fourth	NA
W-4	28-Jul-80	92.0	90.0	75-90	First	NA
W-5	24-Oct-80	93.5	90.0	56-71	First	NA
				81-86	Second	
W-5A	09-Apr-84	115.0	105.0	95-105	Third	NA
W-7	03-Oct-80	110.5	100.5	76-81	First	NA
				88-98	Second	
W-8	14-May-81	110.0	105.0	72-77	Second	NA
				92-102	Third	
W-10A	08-Sep-80	110.7	110.0	85-95	Second	NA
				100-105	Third	
W-11	03-Jun-81	252.0	191.0	136-141	First(?)	NA
				177-187	Second(?)	
W-12	14-Aug-80	115.75	115.0	99-114	First	NA
W-17	08-Oct-80	114.0	114.0	94-109	First	NA
W-17A	20-May-81	181.4	160.0	127-132	Second	NA
				147-157	Third	
W-19	19-Sep-80	164.75	161.0	147-157	First	NA
W-101	25-Jan-85	77.0	72.0	62-72	First	1
W-102	12-Feb-85	396.5	171.5	151.5-171.5	Third	40
W-103	14-Feb-85	96.0	89.5	79.5-89.5	First	5
W-104	21-Feb-85	61.5	56.5	38.75-56.5	First	2.5
W-105	26-Feb-85	69.0	62.0	42-62	First	0.7
W-106	06-Mar-85	144.0	134.5	127.5-134.5	First	0.1-0.2
W-107	13-Mar-85	128.0	122.0	115-122	First	1-3
W-108	21-Mar-85	113.5	69.0	57-69	First	10

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-110	26-Apr-85	371.0	365.0	340-365	Eighth	6
W-111	02-May-85	122.0	117.0	97-117	First	1.5
W-112	10-May-85	129.0	123.5	111-123.5	First	4
W-113	16-May-85	124.0	115.0	100-115	First	0.9
W-114	23-May-85	70.5	63.0	51-63	First	0.5
W-115	03-Jun-85	106.0	95.0	88-95	Second	1.1
W-116	14-Jun-85	181.0	91.0	86-91	First	0.3
W-117	27-Jun-85	202.0	148.0	138-148	First	0.2
W-118	19-Jul-85	206.5	110.0	99-110	Second	8
W-119	02-Aug-85	139.0	102.5	87.5-102.5	Second	3.3
W-120	19-Aug-85	195.0	153.0	147-153	Fourth	1
W-121	23-Aug-85	194.0	171.0	159-171	Fourth	3.75
W-122	17-Aug-85	189.0	132.0	125-132	Fourth	15
W-123	01-Oct-85	174.0	47.7	37.3-47.7	First	5
W-141	23-Mar-85	61.5	60.0	45-60	First	0.8
W-142	29-Mar-85	74.2	72.0	62-72	First	0.8
W-143	12-Apr-85	130.0	126.0	121-126	Second	0.8
W-146	16-Jul-85	225.0	125.0	115-125	Second	5
W-147	26-Jul-85	137.0	87.0	77-87	First	0.5
W-148	08-Aug-85	152.0	98.0	83-98	First	0.5
W-149	23-Aug-85	201.0	169.0	161-169	Fifth	6
W-151	30-Sep-85	237.0	157.5	148.5-157.5	Fourth	1.5
W-201	17-Oct-85	211.0	161.0	151-161	Fifth	14
W-202	07-Nov-85	191.0	109.0	99-109	First	0.5
W-203	15-Nov-85	87.0	41.0	31-41	First	3
W-204	22-Nov-85	110.0	110.0	100-110	First	5+
W-205	09-Dec-85	180.0	117.0	107-117	First	<0.1
W-206	19-Dec-85	188.0	118.0	106-118	Second	<0.5
W-207	24-Jan-86	150.0	85.0	69-85	First	<0.5
W-210	11-Mar-86	176.0	113.0	108-113	First	<0.5
W-211	19-Mar-86	215.5	193.0	183-193	Second	1

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-212	28-Mar-86	183.0	136.0	124-136	First	1
W-213	04-Apr-86	174.0	100.0	94-100	Second	2
W-214	11-Apr-86	146.0	141.5	134-141.5	Fourth	20+
W-217	20-May-86	200.0	112.5	98.5-112.5	First	<0.5
W-218	30-May-86	201.0	71.0	64.5-71	First	6
W-219	13-Jun-86	214.0	148.0	141-148	Third	2
W-220	25-Jun-86	196.0	92.5	82.5-92.5	First	<0.5
W-221	07-Jul-86	178.0	95.0	82-95	First	2
W-222	17-Jul-86	197.0	83.0	63-83	First	5
W-223	15-Aug-86	202.0	153.0	146-153	Third	5.2
W-224	26-Aug-86	199.0	88.0	78-88	First	3
W-225	09-Sep-86	238.0	166.0	152-166	Fourth	2.5
W-226	25-Sep-86	173.0	86.0	71-86	First	<0.25
W-251	03-Oct-85	50.0	47.5	35.5-47.5	First	2
W-252	18-Oct-85	197.0	126.0	108-126	First	3
W-253	30-Oct-85	180.0	128.0	112.5-128	Second	1
W-254	21-Nov-85	277.0	91.5	84.5-91.5	First	5
W-255	05-Dec-85	187.0	124.0	115-124	First	1
W-256	19-Dec-85	187.0	137.0	132-137	Second	<0.5
W-257	15-Jan-86	197.0	96.5	82.5-96.5	First	<0.5
W-258	31-Jan-86	157.0	121.5	116.5-121.5	Third	0.5
W-259	07-Feb-86	200.0	99.0	93.5-99	First	<0.5
W-260	27-Feb-86	215.0	151.0	141-151	Third	3.5
W-261	12-Mar-86	225.0	118.5	109-118.5	First	<0.5
W-262	20-Mar-86	256.0	100.0	91-100	Second	7
W-263	07-Apr-86	146.0	130.0	123-130	Third	2
W-264	14-Apr-86	170.0	151.0	141-151	Fourth	20+
W-265	25-Apr-86	216.0	211.0	205-211	Fifth	3
W-267	27-May-86	196.0	179.0	172.5-179	Seventh	1
W-268	04-Jun-86	213.0	150.5	138-150.5	Third	1
W-269	16-Jun-86	185.0	92.0	79-92	Second	2

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-270	26-Jun-86	185.0	127.0	113-127	First	<0.5
W-271	07-Jul-86	201.0	112.0	105-112	First	2.1
W-272	18-Jul-86	226.0	110.0	95-110	Second	1
W-273	11-Aug-86	203.0	84.0	64-84	First	3
W-274	21-Aug-86	217.0	95.0	90-95	First	<0.5
W-275	05-Sep-86	262.0	184.0	179-184	Fourth	4
W-276	17-Sep-86	267.0	170.0	153.5-169.5	Second	12
W-277	03-Oct-86	254.0	169.0	163-169	Fourth	1.1
W-290	08-Jul-86	181.0	126.0	119.5-126	Second	<0.5
W-291	24-Jul-86	194.0	137.0	127-137	First	<0.5
W-292	14-Aug-86	250.0	184.5	176-184.5	Sixth	9
W-293	27-Aug-86	229.0	155.0	145-155	First	<1
W-294	15-Sep-86	251.0	139.0	122-139	First	1
W-301	07-Oct-86	203.0	141.0	136-141	Fourth	5.5
W-302	22-Oct-86	191.0	83.5	78-83.5	First	2
W-303	28-Oct-86	197.0	128.0	124-128	Second	15
W-304	12-Nov-86	207.0	200.0	195-200	Fifth	1
W-305	18-Nov-86	146.0	138.0	128-138	Second	20
W-306	04-Dec-86	207.0	110.0	98-110	Third	8.5
W-307	15-Dec-86	214.0	102.0	93-102	Second	1
W-308	13-Jan-87	194.0	113.0	107-113	Third	2
W-309	20-Jan-87	73.0	—	—	—	—
W-310	04-Feb-87	202.0	184.5	176.5-184.5	Fourth	10
W-311	20-Feb-87	226.5	147.5	134.5-147.5	Fourth	5
W-312	05-Mar-87	224.5	168.0	160-168	Sixth	25
W-313	12-Mar-87	99.0	85.0	80-85	Third	5.5
W-314	20-Mar-87	228.0	142.0	129-142	Fourth	9.5
W-315	03-Apr-87	215.0	156.0	141-156	Fifth	15
W-316	15-Apr-87	196.0	71.0	66-72	First	3
W-317	20-Apr-87	100.0	95.0	88-95	Second	7

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-318	28-Apr-87	200.0	81.0	74-81	First	0.5
W-319	05-May-87	198.0	125.0	119-125	Fourth	25
W-320	11-May-87	106.0	99.0	94-99	Third	3
W-321	29-May-87	356.0	321.5	305-321.5	Tenth	60
W-322	01-Jul-87	565.5	152.0	142-152	Fourth	4
W-323	04-Aug-87	200.0	127.0	122-127	Third	7
W-324	17-Aug-87	219.0	189.0	184-189	Fifth	15
W-325	28-Aug-87	312.0	170.0	158-170	Second	4
W-352	29-Oct-86	235.0	201.0	181-201	Third	12.5
W-353	12-Nov-86	205.0	101.0	95.5-101	Third	1
W-354	24-Nov-86	185.0	179.0	163-179	Third	8
W-355	05-Dec-86	202.0	107.0	102-107	Third	2
W-356	18-Dec-86	237.0	137.0	133-137	Fourth	6
W-359	10-Feb-87	195.0	150.5	138-150.5	Second	10
W-360	24-Feb-87	260.0	204.5	181.5-204.5	Sixth	30
W-361	05-Mar-87	257.0	135.0	125-135	Fourth	4
W-362	13-Mar-87	151.0	145.0	131-145	Second	12
W-363	24-Mar-87	195.0	129.0	117-129	Second	<0.5
W-364	31-Mar-87	195.0	165.0	155-165	Third	5
W-365	09-Apr-87	187.0	125.0	120-125	Fifth	8.5
W-366	20-Apr-87	273.0	251.0	240-251	Eighth	13
W-368	06-May-87	206.0	78.0	70-78	Second	3
W-369	14-May-87	204.0	113.0	107-113	Third	2
W-370	29-May-87	286.0	208.0	196.5-208	Fifth	5
W-371	12-Jun-87	233.0	162.0	155-162	Fourth	1.5
W-372	25-Jun-87	218.0	152.5	147.5-152.5	Fifth	1
W-373	06-Jul-87	178.0	99.0	89-99	Second	7
W-375	29-Jul-87	223.0	71.0	65-71	Second	0.75
W-376	27-Aug-87	249.0	172.0	162-172	Fourth	2

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-377	04-Sep-87	159.0	144.0	141.5-144	Fourth	2.5
W-378	09-Sep-87	155.0	150.0	146-150	Fifth	5
W-379	14-Sep-87	155.0	150.0	146-150	Fifth	5
W-380	01-Oct-87	195.0	182.0	170-182	Fifth	10
W-401	05-Nov-87	159.0	153.0	109-153	Fourth	25
W-402	13-Oct-87	104.0	102.0	92-102	Third	40
W-403	16-Nov-87	585.0	495.0	485-495	Fifteenth	3
W-404	04-Dec-87	245.0	158.0	150-158	Fourth	33
W-405	04-Jan-88	244.0	162.0	132-162	Fourth	50
W-406	20-Jan-88	213.0	94.0	79-84	First	2
W-407	04-Feb-88	215.0	205.0	192-205	Eighth	4
W-409	07-Mar-88	272.0	78.0	71-78	Third	30
W-410	30-Mar-88	369.0	205.0	193-205	Seventh	35
W-411	12-Apr-88	192.0	138.0	131-138	Second	8
W-412	18-Apr-88	104.0	74.0	67-74	First	2.5
W-413	28-Apr-88	163.0	115.0	100-115	Fourth	25
W-414	20-May-88	179.0	74.0	69.5-74	First	0.5
W-416	10-Jun-88	152.0	80.5	72-80.5	Third	30
W-417	20-Jun-88	152.0	60.0	51-60	Third	5
W-418	24-Jun-88	124.0	118.0	108-118	Third	2.5
W-419	29-Jun-88	82.0	75.5	62.5-75.5	First	3
W-420	26-Jul-88	127.0	111.0	105-111	Third	5
W-421	23-Aug-88	181.0	90.0	75-90	Third	4.5
W-422	02-Sep-88	203.0	139.5	133-139.5	Second	5
W-423	09-Sep-88	308.0	118.0	106-118	Third	14
W-424	04-Oct-88	208.0	144.0	137-144	Fourth	3
W-441	14-Oct-87	250.0	144.0	135-144	First	2.5
W-446	18-Dec-87	202.0	196.0	186-196	Fifth	3
W-447	05-Feb-88	353.0	274.0	256-274	Third	5
W-448	17-Feb-88	235.0	127.5	120.5-127.5	Second	15

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-449	07-Mar-88	172.0	165.0	152-165	Third	3
W-450	21-Mar-88	300.0	200.0	193-200	Third	2
W-451	06-Apr-88	202.0	112.0	106-112	First	1.5
W-452	15-Apr-88	210.0	79.5	64-79.5	First	5
W-453	27-Apr-88	185.0	130.3	121-130	Second	4
W-454	09-May-88	196.0	83.5	73-83.5	Second	3
W-455	19-May-88	184.0	162.5	148-162.5	Fourth	5
W-456	09-Jun-88	343.0	180.5	172-180.5	Third	2
W-457	22-Jun-88	289.0	149.5	130-149.5	First	20
W-458	30-Jun-88	212.5	116.0	108-116	Second	2
W-459	20-Jul-88	76.0	73.0	59.5-73	First	1.5
W-460	22-Jul-88	361.0	140.5	135-140.5	Third	30
W-461	16-Aug-88	133.0	51.5	41.5-51.5	First	<0.5
W-462	12-Sep-88	385.0	336.5	331-336.5	Eighth	5
W-463	16-Sep-88	93.0	92.5	87-92.5	First	5
W-464	30-Sep-88	253.0	104.5	96-104.5	Second	3.5
W-481	04-Nov-88	224.5	105.0	100-105	Second	2
W-482	15-Jan-88	218.0	170.0	165-170	Fifth	<0.5
W-483	26-Jan-88	140.0	130.0	115-130	Second	2.5
W-484	11-Feb-88	255.0	188.0	185-188	Third	0.5
W-485	25-Feb-88	249.0	157.0	151-157	Third	2
W-486	11-Mar-88	167.0	108.0	100-108	Third	2
W-487	17-Mar-88	180.0	151.0	148-151	Sixth	1
W-501	13-Oct-88	174.0	92.0	84-92	Second	6.5
W-502	25-Oct-88	158.0	59.0	55-59	First	<0.5
W-503	02-Nov-88	187.0	80.0	74-80	Second	1
W-504	21-Nov-88	358.0	167.0	157-167	Fourth	3
W-505	15-Dec-88	278.0	180.0	167-180	Fourth	60
W-506	22-Dec-88	120.0	115.0	101-115	Second	30
W-507	18-Jan-89	158.0	139.0	129-139	Third	50

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-508	17-Feb-89	316.0	305.0	287-305	Seventh	60
W-509	03-Mar-89	305.0	184.0	179-184	Fourth	1
W-510	15-Mar-89	300.0	119.0	111-119	Second	<0.5
W-511	31-Mar-89	316.0	176.0	167-176	Third	1
W-512	13-Apr-89	261.0	176.0	166-176	First	2.5
W-513	26-Apr-89	259.0	115.0	102-115	First	1
W-514	17-May-89	386.0	115.5	92-115.5	Second	2
W-515	30-May-89	211.0	78.0	68-78	Third	3.5
W-516	09-Jun-89	203.0	119.0	114-119	Fourth	15
W-517	20-Jun-89	215.0	88.0	80-88	Second	6.7
W-519	14-Aug-89	186.5	80.5	60-80.5	Third	25
W-551	18-Oct-88	308.0	155.5	151-155.5	Third	20
W-552	25-Oct-88	70.5	64.0	48.5-64	First	3
W-553	03-Nov-88	186.0	106.5	99-106.5	Fifth	1
W-554	22-Nov-88	239.0	141.5	126.5-141.4	Third	60
W-555	05-Dec-88	122.0	116.5	102.5-116.5	Second	20
W-556	15-Dec-88	192.0	81.5	76-81.5	Second	6
W-557	22-Dec-88	122.5	118.0	102-118	First	2
W-558	17-Jan-89	117.0	110.5	101-110.5	Second	20
W-559	24-Jan-89	105.0	100.0	93-100	First	0.75
W-560	07-Feb-89	263.0	206.5	201-206.5	Fourth	10
W-561	23-Feb-89	180.0	152.0	143-152	Fourth	4
W-562	08-Mar-89	263.0	158.0	145-158	Third	2
W-563	17-Mar-89	192.0	105.0	95-105	First	2
W-564	30-Mar-89	184.0	85.0	79.5-85	Third	3
W-565	06-Apr-89	177.0	82.5	75-82.5	Second	15
W-566	19-Apr-89	317.0	207.0	197-207	Fifth	12
W-567	27-Apr-89	194.0	61.5	51-61	First	10
W-568	05-Jun-89	156.0	101.0	97-101	First	30
W-569	16-May-89	215.0	109.5	101-109.5	Third	4
W-570	09-Jun-89	180.0	175.0	161-175	Fifth	1

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-571	15-Jun-89	223.5	207.5	102-107	Fourth	22
W-591	29-Nov-88	112.0	107.5	97-107.5	First	<0.5
W-592	12-Dec-88	136.5	113.0	101-113	First	1.5
W-593	06-Feb-89	159.0	92.5	82-92.5	Third	1.5
W-594	27-Feb-89	156.0	61.0	55-61	First	0.5
W-604	27-Nov-89	111.0	83.0	76-82	First	0.5
W-605	08-Dec-89	246.0	136.0	130-136	Third	10
W-606	21-Dec-89	145.0	89.0	73-89	First	2
W-607	24-Jan-90	186.0	55.0	49-55	First	3
W-608	07-Feb-90	162.0	66.0	55-66	First	3
W-610	16-Mar-90	453.0	84.5	69-84.5	First	4
W-611	04-Apr-90	161.0	98.0	87.5-98	Second	2
W-612	19-Apr-90	222.0	136.0	126-136	Fifth	10
W-613	02-May-90	93.0	88.0	81.5-88	Second	7
W-614	18-May-90	262.0	123.0	100-123	Third	12
W-615	01-Jun-90	121.0	99.0	91-99	First	3
W-616	14-Jun-90	255.0	188.0	178-188	First	8
W-617	26-Jun-90	200.0	110.0	103-110	Third	6
W-618	17-Jul-90	357.0	205.0	201-205	Fourth	10
W-619	07-Aug-90	330.0	252.0	232-252	Ninth	30
W-620	30-Aug-90	206.0	88.5	75-88.5	First	5
W-621	09-Sep-90	149.0	120.0	113-120	Second	4
W-622	28-Sep-90	206.0	112.0	104-112	First	<0.5
W-651	22-Feb-90	155.0	89.0	82-89	Second	0.5
W-652	15-Mar-90	318.0	256.0	245-256	Seventh	2
W-653	29-Mar-90	225.0	128.0	122-128	Fourth	0.5
W-654	11-Apr-90	240.0	158.0	140-158	Fifth	20
W-655	25-Apr-90	193.0	130.0	121-129.5	Fourth	2
W-702	24-Oct-90	180.5	95.0	77-95	Second	10
W-703	03-Dec-90	586.0	325.0	298-325	Thirteenth	10
W-705	26-Dec-90	126.00	90.0	77-90	First	2

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-706	16-Jan-91	178.0	84.0	71-84	Second	2
W-714	02-Jul-91	135.0	128.0	107-128	Second	7.5
W-712	29-Aug-91	200.0	185.5	170-185.5	Fifth	8
W-901	24-Feb-93	97.8	88.0	79-83	Second	1
W-902	22-Jan-93	95.5	88.0	80-83	Second	1
W-903	28-Apr-93	223.0	145	132-140	Third	20
W-904	06-May-93	212.0	154.0	121-133 140-149	Thrd	20
W-905	07-Apr-93	221.0	144.5	134-144	Third	4
W-908	18-Aug-93	239.0	197.0	180-197	Fifth	<0.5
W-909	4-Nov-93	252.0	113.5	80.5-108.5	First	2
W-911	20-Dec-93	180	113.5	73.5-108.5	Second	3
W-912	7-Oct-93	239	174	168-174	Fifth	3
W-913	8-Dec-93	454	255	235-255	Third	25
W-1001	20-Dec-93	105	92	85-92	First	1.4
W-1002	31-Jan-94	292.5	260	246-260	Second	16
W-1003	8-Feb-94	184.0	147	140-147	Third	1.5
W-1004	23-Feb-94	99.0	97.0	71-91	First	7
W-1005	14-Mar-94	192.0	110.0	98-110	Second	20
W-1006	10-Mar-94	154.0	149.0	141-149	Second	15
W-1007	31-Mar-94	199.5	182.0	172-182	Third	2
W-1008	13-April-94	246	238	229.5-238	Fifth	10
W-1009	02-May-94	191	140	134-140	Third	20
W-1010	24-May-94	463	142	128-142	Second	20
W-1011	06-June-94	106	89	75-89	First	3
W-1012	20-June-94	161	117	96-112	Second	5
W-1013	29-June-94	147	73	65-73	First	1.4
W-1014	12-July-94	99	89	65-89	Second	30
W-1015	10-Aug-94	437	94	84-94	Second	20
W-1101	10-Nov-94	200.0	79.0	76.0-79.0	Second	0.5
W-1102	29-Nov-94	163.0	95.5	76.0-94.0	Second	8

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
W-1103	15-Dec-94	200.0	82.0	70.0-82.0	Second	3.5
TW-11	09-Jun-81	112.5	107.0	97-107	First	NA
TW-11A	16-Mar-84	163.0	160.0	133-160	Second	NA
TW-21	12-Jun-81	111.5	95.0	85-95	First	NA
GEW-710	02-Aug-91	159.0	158.0	94-137	First thru third	25
GSW-1A	12-Jun-86	208.0	133.0	115-133	Second	12
GSW-2	14-Feb-85	113.0	107.0	87-107	First	NA
GSW-3	07-Feb-85	115.0	105.0	85-105	First	NA
GSW-4	22-Feb-85	112.0	106.0	86-106	First	NA
GSW-5	19-Mar-85	110.0	104.0	94-104	First	NA
GSW-6	28-Feb-86	212.0	137.0	121-137	Third	6
GSW-7	14-Mar-86	176.5	123.4	110.8-123.4	Second	2
GSW-8	01-Apr-86	176.0	133.0	127.5-133	Third	2
GSW-9	14-Apr-86	197.5	152.5	147-152.5	Third	1
GSW-10	29-Apr-86	205.5	127.5	114-127.5	Second	8
GSW-11	07-May-86	182.5	126.0	116-126	Second	2
GSW-12	27-May-86	205.0	191.0	186.5-191	Fourth	1
GSW-13	27-Jun-86	198.0	134.5	125-134.5	Second	1
GSB-14	17-Jul-86	141.0	—	—	—	—
GSW-15	14-Aug-87	148.0	145.0	20.5-28	First	3.5
				38-44	and	
				50-56	second	
				60-64		
				68-73		
				77-83		
				95-105		
				120-130		
GSW-16	19-Oct-87	146.0	145.0	23-28	First	20.5-30
				38-43	and	
				50-55	Second	

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
				61-66		
				78-83		
				95-105		
				120-130		
GSW-208	06-Feb-86	211.0	123.0	108-118	First	<2
GSW-209	27-Feb-86	204.0	135.2	112.8-132.8	First	2
GSW-215	22-Apr-86	213.5	133.5	127-133.5	Third	2
GSW-216	09-May-86	193.0	120.5	110.5-120.5	Second	3
GSW-266	08-May-86	220.0	166.0	159-166	Fourth	1
GSW-326	02-Oct-87	230.0	134.0	129-134	First	0.5
GSW-367	29-Apr-87	159.0	124.0	114-124	Second	2
GSW-374	03-Aug-87	20.0	–	–	–	–
GSW-403-6	11-May-84	138.0	113.6	90-110	First	NA
GSW-442	27-Oct-87	270.0	145.0	138-145	Third	0.5
GSW-443	09-Nov-87	291.0	141.0	123-141	Third	5
GSW-444	20-Nov-87	278.0	120.0	110-120	First	0.3
GSW-445	09-Dec-87	319.0	161.0	155-161	Fourth	3
GSP-801	23-Dec-91	144.0	127.5	116-127.5	Second	NA
GSP-802	23-Dec-91	148.0	128.0	98-128.0	First and second	NA
DYNAMIC STRIPPING PROJECT WELLS [c]						
GSP-GP-801	18-Dec-91	143.9	127.5	116-127.5	Third	NA
GSW-809	30-Jan-92	141.0	141.0	–	–	–
GSP-SNL-001	7-Jan-92	147.0	104.0	99-104	First	NA
			131.0	118-131	Third	NA
TEP-GP-001	21-Jan-92	165.0	97.0	87-97	First	NA
			117.0	107-117	Second	–
			160.5	–	–	–
TEP-GP-003	28-Jan-92	161.0	129.5	124.5-129.5	Third	NA
			161.0	–	–	–
TEP-GP-004	5-Feb-92	161.0	106.0	96-106	First	NA
			134.0	124-134	Third	NA
			161.0	–	–	–

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
TEP-GP-005	18-Feb-92	161.0	124.5	114.5-124.5	Third	NA
			161.0	–	–	–
TEP-GP-006	26-Feb-92	161.0	127.0	107-127	Third	NA
			161.0	–	–	–
TEP-GP-007	13-Mar-92	161.0	161.0	–	–	–
TEP-GP-008	3-Mar-92	161.0	110.0	100-110	First	NA
			161.0	–	–	–
TEP-GP-009	6-May-92	161.7	107.0	98-107	First	NA
			130.5	120.5-130.5	Third	NA
			161.0	–	–	–
TEP-GP-010	24-Mar-92	161.0	124.5	114.5-124.5	Second	NA
TEP-GP-011	7-Apr-92	161.0	108.0	98-108	First	NA
			161.0	–	–	–
GEW-808	5-Jun-92	164.0	150.0	50-140	Unsat. first thru third	25
GEW-816	3-Jun-92	161.7	150.0	50-140	Unsat. first thru third	40
GIW-813	25-Jun-92	140.7	87.0	67-87	Unsat.	–
			104.0	89-99	First	NA
			127.0	107-127	Third	NA
GIW-814	19-Jun-92	149.6	106.5	86.5-106.5	Unsat.	–
			117.0	110-120	First	NA
			132.0	121-141	Third	NA
GIW-815	15-Jun-92	143.0	97.0	77-97	Unsat.	–
			117.0	102-112	First	NA
			132.0	112.8-132	Third	NA
GIW-817	29-Jun-92	150.1	102.0	82-102	Unsat.	–
			122.0	107-117	First	NA
			141.0	121-141	Third	NA
GIW-818	6-Jul-92	150.0	102	82-102	Unsat.	–
			125	110-120	First	NA
			140	120-140	Third	NA
GIW-819	10-Jul-92	150.0	98.6	78.6-98.6	Unsat.	–
			123	108-118	First	NA
			141	121-141	Third	NA
GIW-820	16-Jul-92	143.3	105	85-105	Unsat.	–
			132	112-132	Third	NA
HW-GP-001	17-April-92	120.0	77.0	67-77	Unsat.	–
			113.0	103-113	Confining	–

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
HW-GP-002	13-May-92	120.0	78.0 117.0	68-78 107-117	Unsat. Confining	– –
HW-GP-003	20-May-92	119.0	76.5 119.0	66.5-76.5 109-119	Unsat. Confining	– –
HW-GP-102	13-Aug-93	140.0	137.5	72.5-133.5	First thru third	
HW-GP-103	23-Aug-93	138.0	137.5	71.5-132.5	First thru third	
HW-GP-104	2-Sep-93	138.0	137.2	72.2-132.2	First thru third	
HW-GP-105	28-Sep-93	138.0	137.5	72.5-132.5	First thru third	
TEP-GP-106	21-Sep-93	137.5	135.5			
EXTRACTION WELLS						
W-109	02-Apr-85	289.0	147.0	137-147	Fourth	12
W-351	17-Oct-86	191.0	151.0	146-152	Fourth	2.9
W-357	12-Jan-87	197.0	123.0	107-123	Third	8
W-408	16-Feb-88	131.0	122.5	101-122.5	Second	35
W-415	12-Aug-88	205.0	183.7	79-179	First thru sixth	>50
W-518	08-Aug-89	251.0	139.0	131-139	Second	2.5
W-520	30-Aug-89	160.0	101.5	94-101.5	Second	12
W-521	13-Sep-89	166.0	95.0	86-95	Second	1
W-522	05-Oct-89	145.5	141.5	134-141.5	Third	25
W-601	13-Oct-89	146.0	96.0	88-96	Second	15
W-602	06-Nov-89	168.0	100.0	90-100	Second	10
W-603	15-Nov-89	150.0	147.0	141-147	Third	5
W-609	21-Feb-90	120.0	112.0	104-112	Third	4
W-701	10-Oct-90	159.0	86.0	74-86	Second	10
W-704	01-Feb-91	135.0	107.0	67-76 88-97	First and second	20
W-906	27-Jul-93	200.0	132.0	58-132	First and Second	10
W-907	2-Sep-93	239.0	220.0	172.7-188.8 204.5-215.0	Fourth and Fifth	25
OTHER WELLS						
7D2	07-Jun-76	74	72.3	63.2-67.3	NA	NA

Table A-1. (Continued)

Well No.	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored[a]	Well development flow rate (gpm)[b]
11C1	08-Jun-76	68	66.2	56.2-61.2	First	NA
11H5	08-Nov-85	NA	255	NONE	NA	NA
11J2	26-Apr-79	112	110	90-92	First	NA
				102-108	Second	
11Q4	NA	NA	NA	NA	NA	NA
11Q5	NA	NA	NA	NA	NA	NA
14A3	07-Dec-77	NA	110	100-105	NA	NA
14A11[d]	NA	NA	NA	NA	NA	
14B1	13-Aug-59	300	234(?)	146-149	NA	NA
				192-195		
				198		
				200		
				203		
				205		
				207		
				209-213		
				226		
				230		
				234		
14B4	Aug-60	NA	260	143-148	NA	NA
				155-159		
				186-189		
				205-215		
				245-250		
14B7	NA	NA	NA	NA	NA	NA
14H1	NA	NA	288	NA	NA	NA
14H2[d]	NA	NA	NA	NA	NA	
18D1[d]	NA	NA	NA	NA	NA	NA

[a] Water-bearing zones are numbered consecutively downward from ground surface. A water-bearing zone is considered to consist of saturated permeable materials greater than about 3 ft thick separated from other permeable materials above and below by at least 5 ft of low permeability silt or clay. Due to the lateral and vertical heterogeneity of alluvial deposits, zones with the same water-bearing zone number are not necessarily connected hydraulically.

[b] Flow rate after 4 h of air-lift pumping/surging.

[c] Wells installed for the Dynamic Underground Stripping Demonstration Project include extraction wells (GEW series), injection wells (GIW series), temperature monitoring wells (TEP series), and heating wells (HW series).

[d] Well number was changed in December 1988 to be consistent with Alameda County Flood Control and Water Conservation District, Zone 7 well identification. Well number changes made on this table are:

14A6 ------>14H2

18D81------>18D1

14A84------>14A11

Note: Boreholes B-707, B-708, B-709, B-713, B-715, and B-750 were drilled for the Dynamic Underground Stripping Demonstration Project "Clean Site."

Table A-2. Well closure data, Lawrence Livermore National Laboratory and vicinity, Livermore, California.

Well No.	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored	Closure date
MONITOR WELLS						
W-14A	26-Aug-80	111.0	109.0	80,95,105	First, second, and third	11-Dec-87
W-15	17-Nov-80	285.0	267.0	239-265	Fourth(?)	13-May-88
W-18	22-Aug-80	161.0	152.5	80-90	First	11-Nov-85
				100-105	Second	
				112-117	—	
				128-133	Third	
				143-153	Fourth	
GSW-1	5-Feb-85	112.0	109.0	85-106	First	06-Jun-86
GSW-20	18-May-84	134.0	101.3	95-101.3	First	03-Sep-87
W-150	13-Sep-85	212.0	162.0	157-162	Fifth	11-Apr-90
W-358	04-Feb-87	248.0	239.0	230-239	Fifth	15-Apr-94
EXTRACTION WELLS						
GEW-711	24-May-91	167.5	157.0	94-137	First and second	16-Jun-92
OTHER WELLS						
1N1	15-Jan-48	600	600	427-442	NA	21-Oct-88
				450-453		
				465-469		
				500-515		
				575-588		
11A1	08-Jun-76	66	64.7	54.7-59.7	First	18-Aug-88
11A5	NA	NA	NA	NA	NA	19-Jul-88
11BA[a]	NA	NA	NA	NA	NA	10-Jun-87
11H1	04-Nov-41	NA	519	157-161	NA	31-Oct-88
				169-177		
				224-228		
				243-245		
				254-256		
				306-314		

Table A-2. (Continued)

Well No.	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored	Closure date
				319-327		
				339-342		
				414-419		
				424-431		
				477-479		
11H4	05-Apr-60	272	272	166-170	NA	07-Oct-88
				174-176		
				183-185		
				200-202		
				211-214		
				224-230		
				250-252		
				260-265		
11J1	1941	160(?)	NA	NA	NA	03-Aug-88
11J4[b]	1965	NA	NA	NA	NA	11-Oct-88
11K1	06-Jan-42	NA	621	247-255	NA	26-Sep-88
				272-276		
				297-304		
				322-339		
				554-557		
				580-602		
11K2	NA	NA	232	NA	NA	03-Oct-88
11Q2	NA	NA	264	NA	NA	16-Aug-88
11Q3	NA	NA	120(?)	NA	NA	10-Aug-88
11Q6[b]	NA	NA	280(?)	NA	NA	11-Jan-89
11R3	08-May-61	140	117	NA	NA	03-Sep-85
11R4	NA	NA	NA	NA	NA	03-Sep-85
11R5[b]	NA	NA	NA	NA	NA	26-Jul-85
12M1	09-Dec-42	702	702	375-378	NA	15-Apr-84
				420-426		
				452-473		
				560-564		
				609-621		
				626-657		
12N1	14-Apr-42	702	681(?)	392-399	NA	24-Jan-89

Table A-2. (Continued)

Well No.	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Water-bearing zone monitored	Closure date
				514-518		
				527-536		
				666-670		
				678-681		
13D1[b]	29-Oct-56	NA	400	200-400	NA	23-Aug-88
14A8	NA	NA	86(?)	NA	NA	22-Jul-88
14A1[b]	12-Jul-43	246	227	102-107	NA	13-Sep-88
				113-119		
				144-148		
				176-179		
				188-190		
				192-194		
				219-222		
				223-227		
14A2[b]	15-Nov-56	NA	229	122-130	NA	12-Sep-88
				140-150		
				160-180		
14A4[b]	15-Jun-59	NA	252	167-170	NA	29-Aug-88
				175-179		
				192-202		
				235-246		
14B2	22-Aug-56	NA	312	185-312	NA	11-Nov-88
14B8	NA	NA	385	NA	NA	23-Oct-89

[a] Well not recognized by Alameda County Flood Control and Water Conservation District, Zone 7.

[b] Well number was changed in December 1988 to be consistent with Alameda County Flood Control and Water Conservation District, Zone 7 well identification. Well identification changes made on this table are:

11J81 ---->11J4
11R81------>11R5
11Q81------>11Q6
13D81------>13D1
14A81------>14A1
14A82------>14A2
14A83------>14A4

Appendix B

Results of Hydraulic Tests

Appendix B. Results of hydraulic tests[a].

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
MW-001	1-Dec-83	Drawdown	5.7	2,000	110	Fair
MW-001	23-Jan-85	Drawdown	7.1	3,100	170	Good
MW-001A	22-Jan-85	Drawdown	1.4	190	19	Good
MW-002	1-Dec-83	Slug	0.0	110	34	Poor
MW-002A	24-Jan-85	Drawdown	10.3	2,700	200	Good
MW-004	1-Dec-83	Drawdown	3.3	63	13	Good
MW-005	1-Dec-83	Drawdown	4.3	110	20	Good
MW-005	24-Jan-85	Drawdown	7.9	1,100	210	Fair
MW-005A	23-Jan-85	Drawdown	13.0	1,300	130	Poor
MW-007	1-Dec-83	Slug	0.0	43	14	Fair
MW-008	1-Dec-83	Drawdown	2.9	29	4.9	Fair
MW-011	1-Dec-83	Drawdown	4.1	130	15	Good
MW-017	1-Dec-83	Slug	0.0	38	2.5	Good
MW-017	21-Feb-86	Slug	0.0	85	5.7	Good
MW-018	1-Dec-83	Drawdown	2.6	20	2.7	Poor
MW-102	25-Mar-86	Drawdown	6.4	1,100	72	Good
MW-102	5-Sep-86	Drawdown	24.0	770	53	Good
MW-102	15-Sep-86	Longterm	27.5	4,200	290	Good
MW-103	25-Apr-86	Drawdown	6.7	15,000	1,500	Good
MW-104	3-Mar-88	Drawdown	5.4	1,200	170	Fair
MW-104	25-Mar-88	Drawdown	3.3	450	45	Fair
MW-105	6-Apr-87	Drawdown	0.8	73	7.3	Fair
MW-106	19-Feb-86	Slug	0.0	7.40	1.3	Excel
MW-107	17-Jun-85	Drawdown	1.0	94	9.4	Poor
MW-108	29-Oct-85	Drawdown	7.9	750	63	Poor
MW-109	5-Mar-86	Drawdown	8.1	3,200	540	Good
MW-109	4-Sep-87	Drawdown	20.0	1,600	270	Good
MW-109	29-Sep-87	Longterm	11.6	130	22	Fair
MW-109	16-Oct-87	Drawdown	8.0	2,300	380	Fair
MW-110	18-Jun-85	Drawdown	5.0	1,300	130	Good
MW-111	13-Jun-85	Drawdown	1.0	370	37	Good
MW-111	21-Nov-85	Drawdown	1.0	37	2.3	Good
MW-112	18-Nov-86	Drawdown	13.4	2,100	170	Fair
MW-112	15-Dec-86	Longterm	13.2	3,100	260	Fair
MW-113	17-Apr-86	Slug	0.0	7.40	1.2	Excel
MW-115	5-Mar-86	Drawdown	1.1	180	30	Good

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity[c] (K) (gpd/sq ft)	Data quality[d]
MW-116	24-Dec-85	Slug	0.0	37	7.5	Good
MW-117	20-Feb-86	Slug	0.0	2	0.4	Good
MW-118	5-Mar-86	Drawdown	10.0	2,100	240	Good
MW-119	8-Aug-85	Drawdown	2.0	1,600	100	Good
MW-120	22-Apr-86	Drawdown	1.1	23	5.6	Poor
MW-121	10-Sep-85	Drawdown	2.0	120	7.5	Good
MW-121	23-Sep-85	Drawdown	4.0	23	1.5	Excel
MW-121	14-Oct-85	Drawdown	3.0	34	2.2	Excel
MW-121	15-Oct-85	Drawdown	4.5	45	3.0	Excel
MW-122	28-Oct-85	Drawdown	10.8	490	49	Good
MW-123	28-Oct-85	Drawdown	5.8	40	4.4	Poor
MW-142	3-Mar-88	Slug	0.0	2,600	330	Excel
MW-143	3-Mar-88	Slug	0.0	1,200	240	Excel
MW-149	9-Sep-85	Drawdown	4.0	120	19	Good
MW-149	11-Sep-85	Drawdown	8.0	95	16	Excel
MW-149	11-Oct-85	Drawdown	4.8	58	9.7	Excel
MW-149	11-Oct-85	Drawdown	7.0	70	12	Good
MW-150	2-Oct-85	Drawdown	3.1	640	210	Fair
MW-150	3-Oct-85	Drawdown	6.0	720	240	Fair
MW-150	10-Oct-85	Drawdown	8.8	630	210	Fair
MW-150	10-Oct-85	Drawdown	12.0	620	210.	Fair
MW-151	28-Oct-85	Drawdown	5.8	550	61	Poor
MW-201	5-Mar-86	Drawdown	10.0	740	86	Excel
MW-203	2-Mar-88	Drawdown	6.6	1,100	110	Good
MW-204	23-Jan-86	Drawdown	1.9	100	15	Fair
MW-205	14-Feb-86	Slug	0.0	5.90	1.9	Good
MW-205	18-Feb-86	Slug	0.0	5	1.9	Good
MW-206	14-Apr-86	Slug	0.0	120	11	Good
MW-207	2-Mar-88	Slug	0.0	380	32	Excel
MW-210	9-Jun-86	Slug	0.0	0.60	0.1	Good
MW-211	22-Oct-86	Drawdown	2.9	37	12	Fair
MW-211	8-Dec-86	Longterrn	1.0	44	15	Fair
MW-212	12-May-86	Drawdown	0.8	18	3.1	Poor
MW-213	22-Apr-86	Drawdown	3.8	190	38	Good
MW-214	7-Oct-86	Longterm	27.6	2,300	350	Good
MW-217	15-Jul-86	Slug	0.0	750	120	Good

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
MW-218	17-Jun-86	Drawdown	11.7	6,400	1,100	Good
MW-218	12-Nov-86	Longterm	7.7	4,000	670	Good
MW-219	15-Jul-86	Drawdown	4.3	620	76	Good
MW-219	23-Feb-87	Longterm	5.2	66	8.0	Fair
MW-220	21-Aug-86	Slug	0.0	28	5.5	Excel
MW-221	5-Aug-86	Drawdown	2.1	120	16	Fair
MW-222	12-Aug-86	Drawdown	16.0	1,700	160	Excel
MW-222	8-Mar-85	Longterm	7.7	1,100	180	Good
MW-223	27-Aug-86	Drawdown	4.0	510	110	Good
MW-224	28-Oct-86	Drawdown	7.6	3,600	400	Excel
MW-225	23-Oct-86	Drawdown	4.0	85	11	Good
MW-225	12-Jan-87	Longterm	2.0	62	8.5	Fair
MW-226	31-Mar-87	Slug	0.0	1,700	160	Fair
MW-252	4-Nov-85	Drawdown	4.0	920	50	Fair
MW-252	19-Nov-85	Drawdown	5.6	800	43	Fair
MW-254	27-Jan-86	Drawdown	4.2	340	38	Fair
MW-254	27-Feb-86	Drawdown	3.2	370	41	Good
MW-255	21-Jan-86	Drawdown	5.0	2,800	250	Fair
MW-255	21-Jan-86	Drawdown	6.0	2,000	180	Fair
MW-255	6-Jan-87	Longterm	2.0	400	36	Fair
MW-256	11-Apr-86	Slug	0.0	11	5.5	Good
MW-257	15-Apr-86	Slug	0.0	120	24	Good
MW-258	5-Jun-86	Slug	0.0	35	9.0	Excel
MW-258	29-Oct-86	Slug	0.0	32	8.0	Good
MW-259	26-Mar-88	Slug	0.0	15	5.0	Good
MW-260	25-Mar-86	Drawdown	3.0	140	22	Good
MW-260	1-Oct-86	Longterm	1.4	120	18	Good
MW-261	27-May-86	Slug	0.0	7	2.3	Excel
MW-262	11-Apr-86	Drawdown	12.5	2,000	250	Excel
MW-262	23-Sep-86	Longterm	22.0	2,750	340	Good
MW-262	27-Apr-87	Longterm	23.1	6,800	810	Good
MW-263	22-Apr-86	Drawdown	1.2	37	7.4	Poor
MW-263	4-Nov-86	Longterm	1.8	76	15	Excel
MW-264	7-May-86	Drawdown	8.1	930	100	Good
MW-264	29-Oct-86	Longterm	23.0	480	50	Good
MW-265	19-May-86	Drawdown	0.7	180	34	Fair

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity[c] (K) (gpd/sq ft)	Data quality[d]
MW-267	2-Jun-86	Drawdown	0.5	420	85	Poor
MW-268	14-Nov-86	Drawdown	5.0	230	18	Good
MW-269	14-Jul-86	Drawdown	5.0	570	95	Good
MW-270	30-Dec-86	Slug	0.0	14	2.0	Good
MW-271	4-Aug-86	Drawdown	5.5	340	76	Fair
MW-272	19-Aug-86	Drawdown	0.8	150	30	Fair
MW-273	27-Aug-86	Drawdown	3.2	600	90	Good
MW-274	25-Mar-85	Slug	0.0	38	7.6	Fair
MW-275	30-Oct-86	Drawdown	7.0	730	150	Fair
MW-275	2-Mar-87	Longterm	5.5	830	170	Fair
MW-276	21-Nov-86	Drawdown	13.0	960	110	Good
MW-276	4-May-87	Longterm	24.0	2,700	300	Fair
MW-277	3-Nov-86	Drawdown	0.9	74	25	Fair
MW-290	5-Jan-87	Slug	0.0	14	4.0	Excel
MW-291	27-Jan-87	Slug	0.0	25	7.1	Fair
MW-292	28-Aug-86	Drawdown	6.0	400	56	Excel
MW-294	29-Dec-86	Drawdown	5.3	5,300	29	Fair
MW-294	29-Dec-86	Drawdown	5.9	5,400	300	Good
MW-301	30-Oct-86	Drawdown	6.0	460	100	Good
MW-302	18-Nov-86	Drawdown	1.0	100	27	Good
MW-302	18-Nov-86	Drawdown	2.0	76	21	Fair
MW-303	12-Nov-86	Drawdown	11.1	210	70	Good
MW-304	13-Mar-87	Drawdown	0.9	74	25	Fair
MW-305	26-Nov-86	Drawdown	19.0	720	72	Excel
MW-305	18-May-87	Longterm	20.1	640	64	Excel
MW-306	31-Mar-87	Drawdown	9.5	270	68	Good
MW-307	26-Mar-87	Drawdown	0.9	66	33	Fair
MW-308	4-Dec-87	Drawdown	2.6	27	5.4	Good
MW-310	17-Feb-87	Drawdown	6.7	58	850	Good
MW-311	19-Mar-87	Drawdown	9.8	130	12	Good
MW-311	17-Nov-87	Longterm	9.9	370	26	Good
MW-312	27-Mar-87	Drawdown	20.5	1,800	300	Poor
MW-312	3-Nov-87	Longterm	18.8	1,700	280	Good
MW-313	25-Mar-87	Drawdown	7.9	3,000	600	Good
MW-313	5-Oct-87	Longterm	9.6	3,400	680	Good
MW-314	10-Apr-87	Drawdown	26.4	2,900	390	Good

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
MW-314	13-Jul-87	Longterm	13.6	2,500	330	Fair
MW-315	9-Apr-87	Drawdown	15.4	150	11	Good
MW-315	5-Jan-85	Longterm	24.5	571	41	Excel
MW-316	4-May-87	Drawdown	7.8	1,400	280	Good
MW-317	12-May-87	Drawdown	12.1	300	43	Fair
MW-317	15-Dec-87	Longterm	8.2	120	17.1	Good
MW-318	7-Aug-87	Slug	0.0	120	16	Good
MW-319	29-Jul-87	Drawdown	48.0	7,200	1,500	Good
MW-320	15-May-87	Drawdown	1.8	58	17	Fair
MW-320	15-May-87	Drawdown	3.0	22	3.7	Fair
MW-320	26-Jun-87	Drawdown	2.1	49	14	Fair
MW-321	28-Jul-87	Drawdown	40.0	6,600	450	Good
MW-322	3-Aug-87	Drawdown	3.1	85	15	Good
MW-323	11-Aug-87	Drawdown	3.4	205	59	Good
MW-324	10-Sep-87	Drawdown	6.6	200	50	Good
MW-325	10-Sep-87	Drawdown	6.0	160	13	Excel
MW-351	12-Nov-86	Drawdown	5.7	27	14	Poor
MW-352	30-Dec-86	Drawdown	20.0	280	14	Good
MW-352	7-Jul-87	Longterm	19.5	120	6.0	Excel
MW-353	20-Nov-86	Drawdown	2.1	60	17	Good
MW-354	30-Dec-86	Drawdown	17.6	2,000	220	Fair
MW-354	30-Dec-86	Drawdown	18.0	2,400	260	Good
MW-354	20-Apr-87	Longterm	17.8	310	34	Good
MW-355	29-Dec-86	Drawdown	2.1	19	5.0	Fair
MW-356	17-Mar-87	Drawdown	5.7	180	59	Good
MW-357	18-Feb-87	Drawdown	15.0	1,300	110	Good
MW-357	21-Jul-87	Longterm	9.2	210	18	Good
MW-358	18-Mar-87	Drawdown	9.2	210	32	Excel
MW-359	9-Mar-87	Longterm	19.0	2,800	290	Fair
MW-359	20-Mar-87	Drawdown	18.6	1,100	110	Good
MW-360	22-May-87	Drawdown	30.0	4,800	210	Excel
MW-361	16-Mar-87	Drawdown	4.3	67	11	Good
MW-361	12-Jan-85	Longterm	5.3	178	30	Good
MW-362	23-Mar-87	Drawdown	16.4	470	49	Good
MW-362	21-Sep-87	Longterm	13.6	370	39	Good
MW-363	24-Jul-87	Slug	0.0	20	3.0	Excel

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
MW-364	8-Apr-87	Drawdown	8.6	51	10	Fair
MW-364	1-Jun-87	Longterm	4.8	110	22	Good
MW-365	14-May-87	Drawdown	10.0	36	15	Fair
MW-366	11-May-87	Drawdown	19.0	780	92	Fair
MW-368	11-May-87	Drawdown	2.9	81	8.5	Fair
MW-369	25-Jun-87	Drawdown	7.0	580	96	Good
MW-369	10-Nov-87	Longterm	5.5	89	18	Good
MW-370	23-Jun-87	Drawdown	4.4	84	10	Fair
MW-371	24-Jun-87	Drawdown	3.3	15	3.0	Good
MW-372	23-Nov-87	Slug	0.0	310	62	Excel
MW-373	28-Jul-87	Drawdown	4.0	660	77	Fair
MW-373	28-Jul-87	Drawdown	6.5	50	6.0	Poor
MW-376	26-Jan-88	Drawdown	2.9	65	8.5	Fair
MW-380	23-Oct-87	Drawdown	4.0	33	4.7	Excel
MW-401	23-Oct-87	Drawdown	42.0	950	24	Excel
MW-402	22-Oct-87	Drawdown	41.0	13,500	1,400	Good
MW-403	3-Dec-87	Drawdown	9.7	370	26	Good
MW-404	4-Feb-85	Drawdown	45.0	3,200	530	Good
MW-405	16-Feb-85	Drawdown	47.2	546	14	Good
MW-406	28-Jan-85	Drawdown	7.4	7,500	940	Fair
MW-407	23-Feb-85	Drawdown	14.4	75	7.5	Fair
MW-408	5-Apr-85	Drawdown	45.0	43,000	3,100	Good
MW-409	22-Mar-85	Drawdown	20.0	230	38	Good
MW-410	28-Apr-85	Drawdown	35.0	6,800	570	Fair
MW-411	5-May-85	Drawdown	14.0	50	83	Good
MW-412	6-May-88	Drawdown	4.1	700	64	Fair
MW-414	27-Jul-85	Slug	0.0	150	38	Good
MW-416	11-Jul-85	Drawdown	50.0	2,600	330	Good
MW-417	27Jun-88	Drawdown	5.3	340	57	Fair
P-420	16-Aug-85	Drawdown	3.5	710	100	Excel
MW-421	12-Sep-85	Drawdown	4.8	320	27	Excel
MW-422	19-Sep-85	Drawdown	8.6	230	42	Good
MW-423	12-Oct-85	Drawdown	22.0	1,500	130	Good
MW-424	17-Oct-85	Drawdown	4.5	130	19	Good
MW-441	30-Oct-87	Drawdown	6.0	500	56	Good
MW-441	13-Apr-88	Drawdown	13.0	2,200	240	Poor

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
MW-441	19-Apr-88	Longterm	14.0	470	52	Good
MW-447	26-Feb-88	Drawdown	7.1	124	850	Poor
MW-448	24-Mar-85	Drawdown	24.5	4,200	600	Good
MW-449	21-Mar-85	Drawdown	6.2	170	11	Good
MW-450	14-Apr-88	Drawdown	3.3	38	650	Fair
MW-451	27-Apr-88	Drawdown	2.1	80	16	Good
MW-452	2-May-88	Drawdown	5.2	310	21	Excel
MW-453	3-May-88	Drawdown	5.8	67	7.4	Fair
MW-455	22-Jun-88	Drawdown	5.8	160	13	Good
MW-456	14-Jul-85	Drawdown	4.5	260	33	Fair
MW-457	29-Jul-85	Drawdown	20.5	450	24	Excel
MW-458	2-Aug-85	Drawdown	0.8	24	150	Fair
MW-460	1-Sep-85	Drawdown	17.0	1,900	380	Fair
MW-461	7-Sep-85	Slug	0.0	690	140	Good
MW-462	27-Sep-85	Drawdown	19.0	360	60	Good
MW-463	11-Oct-85	Drawdown	24.0	1,600	200	Good
MW-464	8-Nov-88	Drawdown	9.0	370	53	Good
MW-481	2-Dec-87	Drawdown	1.1	8	1.7	Good
MW-486	23-Mar-85	Drawdown	6.0	230	30	Good
MW-487	14-Apr-88	Drawdown	2.2	45	15	Good
MW-501	21-Oct-85	Drawdown	9.7	170	21	Good
MW-502	14-Nov-85	Slug	0.0	12	30	Good
MW-503	11-Nov-88	Drawdown	1.3	15	3.0	Fair
P-504	8-Dec-85	Drawdown	10.0	590	84	Good
P-505	21-Mar-89	Drawdown	34.2	653	76	Good
P-506	10-Feb-89	Drawdown	31.0	7,423	460	Good
MW-507	6-Feb-89	Drawdown	39.0	2,900	290	Good
MW-508	29-Mar-89	Drawdown	30.0	47,000	2,600	Good
MW-509	11-May-89	Drawdown	0.9	10	2.0	Fair
MW-510	11-May-89	Slug	0.0	220	110	Good
MW-511	11-May-89	Drawdown	1.7	63	11	Fair
MW-512	27-Apr-89	Drawdown	2.9	85	9.4	Good
MW-513	9-May-89	Drawdown	0.6	33	3.0	Fair
MW-514	26-May-89	Drawdown	1.4	84	530	Fair
MW-515	6-Jun-89	Drawdown	2.8	37	4.2	Fair
MW-516	19-Jun-89	Drawdown	19.5	1,428	286	Good

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
MW-517	27-Jun-89	Drawdown	7.3	370	53	Good
MW-518	10-Aug-89	Drawdown	6.2	1,421	178	Good
MW-519	31-Aug-89	Drawdown	31.5	5,700	475	Excel
MW-520	24-Jan-90	Drawdown	22.8	3,300	560	Excel
MW-521	1-Feb-90	Drawdown	0.6	44	4.9	Fair
P-522	5-Feb-90	Drawdown	20.0	3,700	620	Fair
MW-551	8-Nov-85	Drawdown	37.0	350	88	Good
MW-552	12-Dec-88	Drawdown	38.0	4,700	390	Good
MW-553	17-Nov-85	Drawdown	2.2	55	7.9	Fair
P-554	10-Jan-89	Drawdown	21.5	1,800	150	Good
P-555	28-Dec-88	Drawdown	14.0	460	23	Fair
MW-556	25-Jan-89	Drawdown	17.0	850	170	Fair
P-557	23-Jan-89	Drawdown	1.2	570	36	Poor
P-558	23-Mar-89	Drawdown	24.7	5,200	650	Good
MW-560	8-Mar-89	Drawdown	1.7	30	7.6	Fair
MW-561	13-Mar-89	Drawdown	1.1	12	2.1	Fair
MW-562	28-Mar-89	Drawdown	1.0	16	2.3	Fair
MW-563	31-Mar-89	Drawdown	1.1	14	2.3	Fair
MW-564	26-Apr-89	Drawdown	1.6	44	5.0	Poor
MW-565	18-Apr-89	Drawdown	15.6	1,600	260	Good
MW-566	2-May-89	Drawdown	17.0	780	86	Good
MW-566	31-Aug-93	Longterm	22.5	2580	520	Fair
MW-567	4-May-89	Drawdown	10.4	2,600	320	Excel
MW-568	20-Jun-89	Drawdown	18.3	620	160	Fair
MW-569	24-May-89	Drawdown	2.8	100	15	Fair
MW-570	8-Jun-89	Drawdown	1.1	7	1.1	Fair
MW-571	17-Jul-89	Drawdown	17.7	1,000	200	Excel
P-592	23-Jan-89	Drawdown	2.2	2,200	280	Poor
MW-593	22-Feb-89	Drawdown	2.2	57	11.4	Good
MW-594	16-Mar-89	Slug	0.0	380	54	Excel
P-601	8-Feb-90	Drawdown	22.5	6,900	770	Excel
MW-602	29-Jan-90	Drawdown	24.0	5,300	620	Good
P-603	7-Feb-90	Drawdown	6.1	100	20	Fair
P-604	20-Feb-90	Slug	0.0	380	63	Good
P-605	28-Feb-90	Drawdown	4.8	50	12	Good
P-606	21-Feb-90	Slug	0.0	120	20	Fair

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity [c] (K) (gpd/sq ft)	Data quality[d]
P-607	22-Feb-90	Drawdown	1.4	800	100	Good
MW-608	28-Feb-90	Drawdown	1.2	230	30	Fair
MW-609	9-Mar-90	Drawdown	6.7	470	70	Good
MW-610	28-Mar-90	Drawdown	5.8	5,500	380	Good
MW-611	16-Apr-90	Drawdown	3.5	1,000	110	Fair
MW-612	24-May-90	Drawdown	13.5	550	55	Good
MW-612	05-Apr-94	Longterm	14.0	230	40.0	Good
MW-613	23-May-90	Drawdown	4.8	2,550	360	Good
MW-614	7-Jun-90	Drawdown	6.7	1,650	130	Good
MW-615	21-Jun-90	Drawdown	1.3	130	19	Fair
MW-616	27-Jun-90	Drawdown	2.0	390	40	Fair
MW-617	12-Jul-90	Drawdown	2.8	53	6.8	Good
MW-618	1-Aug-90	Drawdown	1.9	24	4.8	Fair
P-619	30-Aug-90	Drawdown	11.8	190	11	Good
P-620	1-Oct-90	Drawdown	5.8	6,500	650	Good
P-621	4-Oct-90	Drawdown	3.8	310	39	Good
MW-622	12-Oct-90	Slug	0.0	130	16	Fair
P-651	16-Mar-90	Slug	0.0	530	180	Fair
MW-652	22-Mar-90	Drawdown	1.0	11	3.8	Good
MW-653	11-Apr-90	Drawdown	0.3	2	1.9	Fair
MW-654	25-Apr-90	Drawdown	21.7	390	25	Fair
MW-655	12-May-90	Drawdown	12.2	1,000	220	Good
P-701	23-Oct-90	Drawdown	14.5	6,800	650	Good
P-701	3-Oct-92	Step	16.5	5,200	430	Good
P-701	1-Apr-93	Drawdown	24	3,700	370	Good
P-702	29-Nov-90	Drawdown	2.5	150	30	Good
P-702	25-Feb-93	Step	4.6	36	7	Poor
P-703	19-Dec-90	Drawdown	7.0	230	9.1	Good
EW-704	4-Mar-91	Drawdown	19.0	1,800	140	Fair
P-705	20-Feb-91	Drawdown	0.8	40	6.1	Fair
P-706	29-Jan-91	Drawdown	0.2	8	1	Fair
EW-712	25-Feb-92	Drawdown	7.8	750	48	Good
EW-712	18-Mar-93	Longterm	15.1	1440	93	Good
P-714	6-Dec-91	Drawdown	2.9	140	6.7	Good
P-902	25-Mar-93	Drawdown	0.6	6	2	Fair
TW-11	24-Jan-85	Drawdown	0.3	200	20	Good

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmissivity (T) (gpd/ft)	Hydraulic conductivity[c] (K) (gpd/sq ft)	Data quality[d]
TW-11A	24-Jan-85	Drawdown	10.0	3,100	110	Fair
GSW-01	11-Dec-85	Slug	0.0	72	0.2	Fair
GSW-01A	14-Jul-86	Drawdown	13.4	12,000	790	Good
GSW-02	17-Dec-85	Slug	0.0	240	10	Good
GSW-03	23-Dec-85	Slug	0.0	510	41	Good
GSW-04	19-Dec-85	Slug	0.0	17	0.9	Good
GSW-05	12-Feb-86	Slug	0.0	99	9	Excel
GSW-06	23-Iun-86	Drawdown	25.0	4,800	310	Good
GSW-06	16-Jun-87	Longterm	20.0	5,500	350	Good
GSW-07	3-Apr-86	Drawdown	4.3	230	23	Excel
GSW-08	19-Nov-86	Drawdown	2.0	230	38	Good
GSW-09	28-May-86	Drawdown	1.9	500	63	Poor
GSW-10	22-May-86	Drawdown	14.3	21,000	2,000	Good
GSW-11	2-Jun-86	Drawdown	4.7	390	45	Excel
GSW-12	7-Jun-86	Drawdown	0.8	51	11	Fair
GSW-13	4-Aug-86	Slug	0.0	110	13	Excel
GSW-13	8-Aug-86	Slug	0.0	62	7	Good
GSW-15	23-Feb-88	Drawdown	25.8	1,500	190	Good
GSW-208	8-May-86	Drawdown	1.9	440	80	Good
GSW-209	8-May-86	Drawdown	6.1	1,200	120	Good
GSW-215	4-Jun-86	Drawdown	1.9	220	40	Poor
GSW-216	16-Jan-92	Drawdown	10.5	3,500	440	Fair
GSW-266	20-Jun-86	Drawdown	2.1	470	72	Good
GSW-266	18-Nov-86	Drawdown	3.0	450	64	Good
GSW-266	18-Nov-86	Drawdown	4.7	410	59	Good
GSW-367	11-May-87	Drawdown	6.9	200	29	Fair
GSW-403-6	8-Dec-85	Slug	0.0	4	0.2	Good
GSW-442	23-Nov-87	Drawdown	1.2	32	4.6	Good
P-702	25-Feb-93	Step	1-4.6	36	7	Poor
GSW-443	30-Nov-87	Drawdown	10.3	260	8.7	Good
GSW-444	28-Jan-88	Slug	0.0	9	0.86	Good
GSW-445	26-Jan-85	Drawdown	4.7	43	4.30	Fair
GEW-710	23-Sept-91	Step	36.0	4,800	220	Excel
GEW-816	15-Aug-92	Drawdown	39.0	12,000	1,100	Good
EW-415	31-Aug-85	Drawdown	10.0	3,100	78	Fair
EW-704	3-May-91	Drawdown	19.0	1,800	140	Fair

Appendix B. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmissivity (T) (gpd/ft)	Hydraulic conductivity[c] (K) (gpd/sq ft)	Data quality[d]
EW-712	25-Feb-92	Drawdown	7.8	790	50	Good
11H4	15-Jan-85	Drawdown	24.6	2,000	77	Good
11H4	19-Jan-85	Longterm	29.5	1,780	18	Good
11J4	10-Jun-88	Drawdown	17.0	1,000	15	Excel
11J4	14-Jun-85	Longterm	16.0	1,100	16	Good
13D1	9-Feb-85	Longterm	50.0	4,800	48	Excel

a The pumping test results were obtained by using the analytic techniques of Theis (1935), Cooper and Jacob (1946), Papadopulos and Cooper (1967), Hantush and Jacob (1955), Hantush (1960), or Boulton (1963). The particular method used is dependent on the character of the data obtained. The slug test results were obtained using the method of Cooper *et al.* (1967). (See references below.)

b "DRAWDOWN" denotes 1-h pumping tests; "LONGTERM" denotes 24- to 48-h pumping tests; "STEP" denotes a step drawdown test, flow rate given is the maximum or final step.

c K is calculated by dividing T by the thickness of permeable sediments intercepted by the sand pack of the well. This thickness is the sum of all sediments with moderate to high estimated conductivities determined from the geologic and geophysical logs of the well.

d Hydraulic test quality criteria:

Excel: High confidence that type curve match is unique. Data are smooth and flow rate well controlled.

Good: Some confidence that curve match is unique. Data are not too "noisy." Well bore storage effects, if present, do not significantly interfere with the curve match. Boundary effects can be separated from properties of the pumped zone.

Fair: Low confidence that curve match is unique. Data are "noisy." Multiple leakiness and other boundary effects tend to obscure the curve match.

Poor: Unique curve match cannot be obtained due to multiple boundaries, well bore storage, uneven flow rate, or equipment problems. Usually, the test is repeated.

References

Boulton, N. S. (1963), "Analysis of Data from Non-Equilibrium Pumping Tests Allowing for Delayed Yield from Storage," *Proc. Inst. Civ. Eng.* **26**, 469-482.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos (1967), "Response of a Finite-Diameter Well to an Instantaneous Charge of Water," *Water Resour. Res.* **3**, 263-269.

Cooper, H. H., and C. E. Jacob (1946), "A Generalized Graphical Method of Evaluating Formation Constants and Summarizing Well Field History," *Am. Geophys. Union Trans.* **27**, 526-534.

Hantush, M. S. (1960), "Modification of the Theory of Leaky Aquifers," *The J. of Geophys. Res.* **65**, 3173-3725.

Hantush, M. S., and C. E. Jacob (1955), "Non-Steady Radial Flow in an Infinite Leaky Aquifer," *Am. Geophys. Union Trans.* **36** (1), 95-100.

Papadopulos, I. S., and H. H. Cooper, Jr. (1967), "Drawdown in a Well of Large Diameter," *Water Resour. Res.* **3**, 241-244.

Theis, C. V. (1935), "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," *Am. Geophys. Union Trans.* **16**, 519-524.

Appendix C

Ground Water Sampling Schedule for 1995

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-258	Q	Mar-95	Trit,(Cr(VI)(96-A)),601
W-259	Q	Mar-95	Trit(3-96),601
W-260	A	Sep-95	601
W-261	A	Sep-95	(Trit,9/95),601
W-262	Q	Mar-95	601
W-263	S	Mar-95	601
W-264	S	Jun-95	(Cr(VI)(95-A)),601
W-265	A	Jun-95	601
W-267	S	Mar-95	(Cr(VI)(96-A)),601
W-268	A	Sep-95	(Trit,9-95),601
W-269	Q	Mar-95	601
W-270	A	Jun-95	9Trit,3/95),601
W-271	Q	Mar-95	601
W-272	S	Mar-95	624
W-273	A	Sep-95	601
W-274	Q	Mar-95	624
W-275	Q	Mar-95	(Cr(VI)(95-A)),601
W-276	A	Mar-95	624
W-277	A	Mar-95	(Cr(VI)(95-A)),601
W-290	A	Dec-95	601
W-291	A	Dec-95	(Cr(VI)(95-A)),601
W-292	Q	Mar-95	601
W-293	A	Mar-95	601
W-294	A	Mar-95	601
W-301	S	Jun-95	601
W-302	S	Mar-95	(Cr(VI)(95-A)),601
W-303	A	Mar-95	601
W-304	Q	Mar-95	601
W-305	A	Mar-95	601
W-306	A	Dec-95	601
W-307	Q	Mar-95	601
W-308	A	Jun-95	(Cr(VI)(94-A)),601
W-310	A	Sep-95	601
W-311	A	Sep-95	601
W-312	A	Jun-95	601
W-313	S	Mar-95	601
W-314	S	Jun-95	601
W-315	A	Mar-95	(Cr(VI)(96-A)),601

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-316	Q	Mar-95	601
W-317	Q	Mar-95	601
W-318	A	Jun-95	(Cr(VI)(95-A)),601
W-319	A	Dec-95	(Cr(VI)(95-A)),601
W-320	S	Mar-95	(Cr(VI)(95-A)),601
W-321	A	Sep-95	601
W-322	A	Sep-95	601
W-323	A	Mar-95	(Cr(VI)(95-A)),601
W-324	Q	Mar-95	601
W-325	A	Sep-95	601
W-351	Q	TFC	601
W-352	Q	Mar-95	601
W-353	S	Mar-95	(Cr(VI)(95-A)),601
W-354	S	Mar-95	601
W-355	Q	Mar-95	601
W-356	Q	Mar-95	(Trit,9-95),601
W-357	S	Mar-95	(Cr(VI)(95-A)),601
W-359	Q	Mar-95	601
W-360	A	Mar-95	601
W-361	Q	Mar-95	601
W-362	A	Jun-95	601
W-363	Q	Mar-95	Trit(S-6/94),601
W-364	S	Mar-95	601
W-365	Q	Mar-95	601
W-366	A	Mar-95	601
W-368	A	Mar-95	601
W-369	Q	Mar-95	601
W-370	A	Mar-95	601
W-371	A	Sep-95	(Cr(VI)(95-A)),601
W-372	A	Mar-95	(Cr(VI)(96-A)),601
W-373	A	Mar-95	(Cr(VI)(93-A)),601
W-375	Q	Mar-95	(Cr(VI)(95-A)),601
W-376	A	Jun-95	(Cr(VI)(95-A)),601
W-377	Q	Mar-95	601
W-378	Q	Mar-95	(Cr(VI)(96-A)),601
W-379	Q	Mar-95	601
W-380	Q	Mar-95	601
W-401	Q	Mar-95	601

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-402	Q	Mar-95	601
W-403	A	Sep-95	601
W-404	Q	Mar-95	(Cr(VI)(96-A)),601
W-405	Q	Mar-95	601
W-406	S	Mar-95	601
W-407	A	Dec-95	601
W-408	S	TFA	601
W-409	S	Mar-95	(Cr(VI)(95-A)),601
W-410	A	Mar-95	601
W-411	S	Mar-95	601
W-412	S	Jun-95	601
W-413	S	Mar-95	(Cr(VI)(96-A)),601
W-414	A	Sep-95	Trit(95-A), 601
W-416	A	Jun-95	(Cr(VI)(95-A)),601
W-417	A	Jun-95	(Cr(VI)(95-A)),601
W-418	A	Jun-95	(Cr(VI)(95-A)),601
W-419	Q	Mar-95	(Cr(VI)(95-A)),601
W-420	Q	Mar-95	601
W-421	A	Jun-95	(Cr(VI)(95-A)),601
W-422	A	Mar-95	(Cr(VI)(95-A)),601
W-423	Q	Mar-95	601
W-424	Q	Mar-95	601
W-441	A	Collap.	601
W-446	A	Mar-95	601
W-447	Q	Transduc.	601
W-448	Q	Mar-95	(Cr(VI)(96-A)),601
W-449	Q	Mar-95	(Cr(VI)(96-A)),601
W-450	A	Mar-95	601
W-451	S	Mar-95	601
W-452	Q	Mar-95	601
W-453	Q	Mar-95	(Cr(VI)(95-A)),601
W-454	Q	Mar-95	(Cr(VI)(95-A)),601
W-455	A	Mar-95	(Cr(VI)(95-A)),601
W-456	S	Mar-95	(Cr(VI)(96-A)),601
W-457	Q	Mar-95	(Cr(VI)(96-A)),601
W-458	A	Sep-95	(Cr(VI)(95-A)),601
W-459	S	Mar-95	(Cr(VI)(95-A)),601
W-460	Q	Mar-95	(Cr(VI)(96-A)),601

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-461	A	Mar-95	601
W-462	A	Sep-95	601
W-463	S	Mar-95	601
W-464	Q	Mar-95	(Cr(VI)(95-A)),601
W-481	Q	Mar-95	(Cr(VI)(96-A)),601
W-482	S	Mar-95	(Cr(VI)(95-A)),601
W-483	Q	Mar-95	(Cr(VI)(95-A)),601
W-484	A	Sep-95	601
W-485	A	Jun-95	601
W-486	S	Mar-95	(Cr(VI)(96-A)),601
W-487	A	Mar-95	(Cr(VI)(95-A)),601
W-501	S	Mar-95	(Cr(VI)(96-A)),601
W-502	A	Mar-95	(Cr(VI)(95-A)),601
W-503	A	Jun-95	(Cr(VI)(95-A)),601
W-504	A	Mar-95	601
W-505	S	Jun-95	(Cr(VI)(95-A)),601
W-506	Q	Mar-95	601
W-507	A	Sep-95	(Cr(VI)(95-A)),601
W-508	A	Sanded	624
W-509	S	Mar-95	601
W-510	A	Mar-95	(Cr(VI)(93-A)),624
W-511	A	Mar-95	601
W-512	S	Mar-95	601
W-513	Q	Mar-95	601
W-514	A	Jun-95	601
W-515	Q	Mar-95	(Cr(VI)(95-A)),601
W-516	Q	Mar-95	(Cr(VI)(96-A)),601
W-517	Q	Mar-95	(Cr(VI)(96-A)),601
W-518	A	TFA	601
W-519	A	Sep-95	601
W-520	Q	TFA	601
W-521	Q	TFA	601
W-522	S	TFA	601
W-551	Q	Mar-95	601
W-552	Q	Mar-95	601
W-553	Q	Mar-95	(Cr(VI)(96-A)),601
W-554	Q	Mar-95	(Cr(VI)(96-A)),601
W-555	S	Jun-95	601

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-556	A	Jun-95	(Cr(VI)(95-A)),601
W-557	A	Dec-95	601
W-558	Q	Mar-95	601
W-559	A	Dec-95	601
W-560	Q	Mar-95	601
W-561	A	Mar-95	601
W-562	A	Mar-95	Trit 95,601
W-563	A	Mar-95	(Cr(VI)(95-A)),601
W-564	A	Sep-95	(Cr(VI)(95-A)),601
W-565	Q	Mar-95	(Cr(VI)(96-A)),601
W-566	Q	Mar-95	(Trit-6-95),601
W-567	S	Mar-95	601
W-568	Q	Mar-95	(Cr(VI)(96-A)),601
W-569	A	Mar-95	601
W-570	A	Sep-95	601
W-571	S	Mar-95	(Cr(VI)(95-A)),601
W-591	A	Dec-95	(Cr(VI)(95-A)),601
W-592	A	Dec-95	((PB)(95-A)),601
W-593	A	Mar-95	601
W-594	S	Mar-95	601
W-601	Q	TFA	(Cr(VI)(93-A)),601
W-602	Q	TFA	601
W-603	A	TFA	601
W-604	S	Mar-95	601
W-605	Q	Mar-95	(Cr(VI)(96-A)),601
W-606	S	Mar-95	(Cr(VI)(95-A)),601
W-607	A	Mar-95	Trit-(S/9-95),(Cr(VI)(96-A)),601
W-608	S	Mar-95	(Cr(VI)(96-A)),601
W-609	S	TFA	601
W-610	Q	Mar-95	601
W-611	Q	Mar-95	(Cr(VI)(95-A)),601
W-612	S	Mar-95	601
W-613	A	Mar-95	601
W-614	S	Mar-95	601
W-615	A	Sep-95	(Cr(VI)(95-A)),601
W-616	S	Mar-95	601
W-617	Q	Mar-95	601
W-618	A	Sep-95	601

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-619	A	Mar-95	601
W-620	Q	Mar-95	601
W-621	S	Mar-95	601
W-622	Q	Mar-95	(Trit,9/95),601
W-651	S	Mar-95	601
W-652	A	Mar-95	TRIT(3/96),601
W-653	Q	Mar-95	601
W-654	A	Mar-95	(Cr(VI)(95-A)),601
W-655	Q	Mar-95	(Cr(VI)(95-A)),601
W-701	S	TFC	(Cr(VI)(94-A)),601
W-702	S	Mar-95	TRIT-12,(Cr(VI)(95-A)),601
W-703	Q	GAP	None
W-705	Q	Mar-95	601
W-706	A	Sep-95	(Cr(VI)(95-A)),601
W-714	Q	Mar-95	601
W-901	Q	Mar-95	601
W-903	Q	Mar-95	601
W-904	Q	Mar-95	601
W-905	Q	Mar-95	601
W-909	Q	Mar-95	Trit-(S/3-95),601
W-911	Q	Mar-95	Trit-(S/3-95),601
W-912	Q	Mar-95	Trit-(S/3-95),601
W-913	Q	Mar-95	601
W-1001	Q	Mar-95	601
W-1002	Q	Mar-95	601
W-1003	Q	Mar-95	601
W-1003	Q	Mar-95	601
W-1004	Q	Mar-95	601
W-1005	Q	Mar-95	601
W-1006	Q	Mar-95	601
W-1007	Q	Mar-95	601
W-1008	Q	Mar-95	601
W-1009	Q	Mar-95	601
W-1012	Q	Mar-95	601
W-1014	Q	Mar-95	601
W-1015	Q	Mar-95	601
W-1101	Q	Mar-95	601
W-1102	Q	Mar-95	601

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
W-1103	Q	Mar-95	601
EW704	Q	TFB	601
EW-906	Q	Mar-95	NPDES METALS,GM,601
EW-907	Q	Mar-95	NPDES METALS,GM,601
EW-908	Q	Mar-95	601
EW712	Q	Mar-95	601
TW11	Q	Mar-95	601
TW11A	Q	Mar-95	601
TW21	S	Jun-95	601
GSW1A		Request	None
GSW2		Request	None
GSW3		Request	None
GSW4		Request	None
GSW5		Request	None
GSW6		Request	None
GSW7		Request	None
GSW8		Request	None
GSW9		Request	None
GSW10		Request	None
GSW11		Request	None
GSW12		Request	None
GSW13		Request	None
GSW15		Request	None
GSW16		Request	None
GSW208		Request	None
GSW209		Request	None
GSW215		Request	None
GSW216		Request	None
GSW266		Request	None
GSW326		Request	None
GSW367		Request	None
GW4036		Request	None
GSW442		Request	None
GSW-443		Mar-95	601
GSW-444		Request	601
GIW814		Request	None
GIW-815		Request	None
GIW-817		Request	None

Appendix C. (Continued)

Well number	Sampling frequency	Next sample date	Regulatory compliance requested analyses
GIW-818		Request	None
GIW-820		Request	None
7D2	Q	Mar-95	601
11C1	Q	Mar-95	601
11J2	A	Buried	601
14A3	Q	Mar-95	601
14A11	Q	Mar-95	601
14B1	Q	Mar-95	601
14B4	Q	Mar-95	601
14C1	Q	Mar-95	601
14C2	Q	Mar-95	601
14C3	Q	Mar-95	601
14H1	S	Jun-95	601
18D1	S	Jun-95	601

Appendix D

Drainage Retention Basin Monitoring Results: September through December 1994

Appendix D

Drainage Retention Basin Monitoring Results September through December, 1994

This appendix presents the LLNL Environmental Monitoring and Analysis Division quarterly summary of routine maintenance, water quality monitoring data, and discharge data for the Drainage Retention Basin (DRB). In addition, we provide a summary of the maintenance and monitoring performed during 1994. The DRB, located in the central portion of the Livermore Site (Fig. D-1), is a water body with 52.89 megaliters (1.4×10^7 gal, or approximately 43 acre-ft) capacity, which was designed to receive treated ground water and storm water runoff. This quarter we summarize the monitoring activities at the DRB for September through December 1994. Analytical results of the DRB samples collected within the basin are summarized in Table D-1. Analytical results of samples of the water released from the DRB are summarized in Tables D-2 and D-3.

Drainage Retention Basin Maintenance Monitoring

During the fourth quarter of 1994, samples collected at sampling location CDBE (Fig. D-2) exceeded the management action levels (MAL) for two nutrients, turbidity, and two metals (Table D-1). Phosphate concentrations of 0.063 milligrams per liter (mg/L) and 0.05 mg/L exceeded the MAL of 0.02 mg/L in September and November 1994, respectively. Ammonia nitrogen concentrations of 0.2 mg/L, 0.18 mg/L, and 0.34 mg/L exceeded the MAL of 0.1 mg/L in October, November, and December, respectively. Note that the analytical detection limits for nitrate, nitrite, total nitrogen, and phosphate as total phosphorous exceeded the recommended MALs specified in the LLNL DRB Management Plan (Draft Final DRB Management Plan for LLNL prepared by Limnion Corp., December 1991).

Turbidity continued to be below the MAL of 0.914 m throughout the fourth quarter, ranging between 0.28 m and 0.61 m. Turbidity first dropped below management levels during August 1994. Turbidity is expected to continue to be below the MAL until sediment from winter runoff settles.

Semiannual samples collected in October 1994 contained 2.7 mg/L lead, which is slightly above the MAL of 2.0 mg/L. Nickel was detected at 12 mg/L, also exceeding the MAL of 7.1 mg/L. An additional nickel analysis in a sample collected in November 1994 confirmed the nickel concentrations slightly above the MAL.

Dissolved oxygen levels in the DRB continue to be below the recommended MAL of 80% (Fig. D-3). However, operation of the three aeration pumps has maintained dissolved oxygen levels close to the desired saturation level. Figure D-4 shows the dissolved oxygen levels from January through December 1994, measured at three monitoring points representing the top, middle, and bottom elevations of the DRB. Dissolved oxygen levels have remained above the Management Plan critical concentration level of 5 mg/L (Fig. D-3) and are consistent with seasonal fluctuations. Dissolved oxygen levels below 5 mg/L allow anaerobic bacteria to thrive, potentially releasing metals and nutrients from the sediments into the water column.

Temperature fluctuations for January through December 1994 are shown in Figure D-5. The temperatures are relatively uniform with depth because of the mixing due to aeration. Temperatures fluctuate seasonally from a low of about 8°C in the winter months to a high of about 22°C in the summer.

Monthly maintenance conducted by Contra Costa Landscaping (CCL) indicated that the plants within the Nutri-pods were healthy, growing as expected, and filling approximately 40% of the Nutri-pods' capacity. Fish and insect populations existed as expected. The maintenance contract with CCL expired in December 1994. A new contract will be competitively bid during January 1995 and should be in place by February 1995.

TFD began discharging treated ground water to the DRB in September, 1994. A total of 0.36 megaliters (95,367 gal) of treated ground water was discharged to the DRB from September through December 1994.

Improvements to the DRB during 1994 included (1) successful maintenance of the Nutri-pod system; (2) planting of Elodea on the shelves of the DRB; (3) permanent power installation for three aeration pumps, two of which are solar powered; (4) cleaning of the sediment traps at the two influent points to the DRB; (5) diverting surface runoff from Greenville Road away from the eastern influent storm water drain to the DRB and into the perimeter drain; and (6) extensive landscaping around the DRB, including planting over 100 trees and shrubs and stabilization of slopes with redwood chips. Algae was manually removed when chlorophyll a concentrations were high. As the plants in the Nutri-pods and on the shelves grow, we expect to see fewer values above management levels for nutrients, chlorophyll a, and turbidity.

Drainage Retention Basin Discharge Monitoring

Manual releases of water from the DRB occurred on November 14 and December 15, 1994. On November 14, approximately 2.1 megaliters (553,900 gal) of water were released to increase the DRB's storage capacity. On December 15, approximately 23.4 megaliters (6,191,000 gal) of water were released to repair the DRB weir.

Samples were collected at the DRB discharge point (CDBX), and the outfall located in the northwestern corner of the site (WPDC) (Fig. D-1). Samples collected at CDBX represent water quality released from the DRB. Samples collected at WPDC represent the water quality of the released water commingled with any other discharges occurring at the time of release, including storm water runoff and treated effluent from ground water treatment facilities. No rainfall occurred during the November release. However, the December release occurred during stormy conditions and represented only a small portion of the flow at WPDC.

Table D-2 shows the analytical results for samples collected from discharge location CDBX, and Table D-3 shows the analytical results for samples collected at WPDC. During the November release, lead concentrations of 4.5 micrograms per liter (µg/L) exceeded the discharge limit of 2 µg/L in the sample collected at CDBX (Table D-2). Similarly, the sample collected at WPDC contained 10 µg/L lead in November and 19 µg/L in December (Table D-3). The sample collected at CDBX also exceeded the discharge limit for nickel (7.1 μg/L) with concentrations of 10 μg/L in November and 9.5 μg/L in December. Similarly, the samples collected at WPDC contained 40 μg/L nickel in November and 44 μg/L in December. Samples collected at WPDC also slightly exceeded the discharge limits for beryllium, copper, and zinc (Table D-3).

Because most of the water collected in the DRB is storm water, we believe the source of the nickel and lead found in the samples collected at CDBX is from rain water. The metals concentrations in the WPDC probably originate from the sediments in the storm water channels during discharge to the DRB.

This year there were three releases from the DRB totaling 22.2 megaliters (7,235,000 gal) of water. There were 9 days of passive overflow, all occurring during February 1994.

Table D-1. Drainage Retention Basin management results for monitoring point CDBE, September through December 1994.

Analyte	Units	Method	Sampling frequency	Date/analytical results					Action level[a]
				22 Sep 94	10 Oct 94	11 Nov 94	11 Nov 29	29 Dec 94	
Total alkalinity ($CaCO_3$)	mg/L	EPA 310.1	Monthly	86	91		74	74	<50
Chlorophyll a	mg/L	SM 10200 H3	Monthly	*31*	*20*		*18*	29	>10
Nitrate (N)	mg/L	EPA 300.0	Monthly	<0.5	<0.5		<0.5	<0.5	≥0.2[d]
Nitrite (N)	mg/L	EPA 300.0	Monthly	<0.5	<0.5		<0.5	<0.5	≥0.2[c,d]
Ammonia nitrogen	mg/L	EPA 350.2	Monthly	<0.1	*0.2*		*0.18*	*0.34*	>0.1[c]
Total Kjeldahl nitrogen	mg/L	EPA 351.2	Monthly	<0.5	0.82		0.8	0.6	None[c]
Phosphate as phosphorous	mg/L	SM 4500-P.D.	Monthly	*0.063*	<0.05		*0.05*	g	≥0.02[d]
Conductivity	μmhos/cm	EPA 120.1	Monthly	200	210		190	130	900[c]
pH	units	EPA 150.1	Monthly	8.2	7.3		7.6	7.2	> 9.0, < 6.0
Total Suspended Solids	mg/L	EPA 160.2	Monthly	26	9		18	g	None
Total Dissolved Solids	mg/L	EPA 160.1	Monthly	130	160		120	110	>350
Turbidity	meters	Secchi disk	Monthly	*0.46*	*0.61*		*0.61*	*0.28*	<0.914
Chemical Oxygen Demand	mg/L	EPA 410.4	Quarterly	b	110		b	b	None
Oil and grease	mg/L	EPA 413.1	Quarterly	b	<5.0		b	b	>15
Coliform, fecal	MPN/0.1L	SM 9221	Quarterly	b	2		b	b	>400
Coliform, total	MPN/0.1L	SM 9221	Quarterly	b	500		b	b	>5000
Antimony	μg/L	EPA 200.7	Semiannually	b	<60		b	b	1460
Arsenic	μg/L	EPA 206.2	Semiannually	b	3.4	4.3	b	b	20
Beryllium	μg/L	EPA 200.7	Semiannually	b	<.05		b	b	0.7
Boron	μg/L	EPA 200.7	Semiannually	b	100		b	b	500
Cadmium	μg/L	EPA 200.7	Semiannually	b	<0.5		b	b	5
Chromium, total	μg/L	EPA 200.7	Semiannually	b	<10		b	b	50
Chromium, +6	μg/L	EPA 7196	Semiannually	b	<10		b	b	11
Copper	μg/L	EPA 220.2	Semiannually	<50[b]	12	7.9	<50[b]	<50[b]	20
Iron	μg/L	EPA 236.2	Semiannually	<100[b]	1600	1200	<100[b]	<100[b]	3000

UCRL-AR-115640-94-4

Table D-1. (Continued)

Analyte	Units	Method	Sampling frequency	Date/analytical results 22 Sep 94	10 Oct 94	11 Nov 94	11 Nov 29	29 Dec 94	Action level[a]
Lead	µg/L	EPA 200.7	Semiannually	b			b	b	2
Manganese	µg/L	EPA 243.2	Semiannually	<30[b]	57	34	<30[b]	<30[b]	500
Mercury	µg/L	EPA 245.2	Semiannually	b	<0.2		b	b	1
Nickel	µg/L	EPA 200.7	Semiannually	<100[b]	*12*	*8*	<100[b]	<100[b]	7.1
Selenium	µg/L	EPA 270.2	Semiannually	b	<2		b	b	100
Silver	µg/L	EPA 200.7	Semiannually	b	<0.5		b	b	2.3
Thallium	µg/L	EPA 200.7	Semiannually	b	<5		b	b	130
Zinc	µg/L	EPA 200.7	Semiannually	<50[b]	40	42	<50[b]	<50[b]	58
Total VOCs	µg/L	EPA 601 & 602	Semiannually	b	e		b	b	5
Benzene	µg/L	EPA 524.2	Semiannually	b	<0.3		b	b	0.7
Perchloroethylene	µg/L	EPA 524.2	Semiannually	b	<0.5		b	b	4
Vinyl chloride	µg/L	EPA 524.2	Semiannually	b	<0.5		b	b	2
Base/neutral/acid extractables and pesticides	µg/L	EPA 625	Semiannually	b	e		b	b	5
Total petroleum hydrocarbons	µg/L	EPA 8015	Semiannually	b	<50		b	b	50
Polynuclear aromatic hydrocarbons	µg/L	EPA 610	Semiannually	b	e		b	b	15
Ethylene dibromide	µg/L	EPA 504	Semiannually	b	<0.01		b	b	0.02
Total organic carbon	mg/L	EPA 415.1	Semiannually	b	e		b	b	None
Gross alpha	pCi/L		Semiannually	b	f		b	b	15[c]
Gross beta	pCi/L		Semiannually	b	f		b	b	50[c]
Tritium	pCi/L		Semiannually	b	568		568	b	20,000[c]
Fish toxicity	% survival	EPA 600/ 4-5/013	Annually	b	b		b	b	90

Notes:

Italic text denotes concentration limits outside of Management Plan Action Levels.

[a] Action Levels from the DRB Management Plan for LLNL, Limnion's Draft Final, 12/91, Summary of Water Quality Objectives, Table 6. Referenced from the S.F. RWQCB Basin Plan and Guidance Document for Pond, Lagoon, and Lake Management Plan, and from the CA Dept. of Fish and Game's Threshold for the Control of Algae Blooms.

[b] Sample not required in this sampling period.

[c] Water Quality Objectives for Municipal Supply Waters, Table III-2 from the Water Quality Control Plan, S.F. Bay Basin RWQCB, Dec. 1991.

[d] Laboratory's Reporting Limit could not meet Action Level.

[e] All compounds in this group are less than the detection limit.

[f] Analytical results pending.

[g] Sample not analyzed for this constituent.

Table D-2. Analytical results from DRB discharge point CDBX, September through December 1994.

Analyte	Units	Method	Date/analytical results		Discharge limit[a]
			15 Nov 94	14 Dec 94[f]	
Conductivity	μmhos/cm	EPA 120.1	190	180	900[c]
pH	units	EPA 150.1	8.3	7.3	> 9.0, < 6.0
Total Suspended Solids	mg/L	EPA 160.2	29	20	None
Antimony	μg/L	EPA 200.7	<5	5.5	1460
Arsenic	μg/L	EPA 206.2	3.8	3.5	20
Beryllium	μg/L	EPA 200.7	<0.5	<0.5	0.7
Boron	μg/L	EPA 200.7	120	100	500
Cadmium	μg/L	EPA 200.7	<0.5	<0.5	5
Chromium, total	μg/L	EPA 200.7	<10	6.1	50
Chromium, +6	μg/L	EPA 7196	<10	<10	11
Copper	μg/L	EPA 220.2	9.7	6.7	20
Iron	μg/L	EPA 236.2	No analysis	No analysis	3000
Lead	μg/L	EPA 200.7	4.5	<2	2
Manganese	μg/L	EPA 243.2	No analysis	No analysis	500
Mercury	μg/L	EPA 245.2	<0.2	<0.2	1
Nickel	μg/L	EPA 200.7	10	9.5	7.1
Selenium	μg/L	EPA 270.2	<2	<2	100
Silver	μg/L	EPA 200.7	<0.5	<0.5	2.3
Thallium	μg/L	EPA 200.7	<5	<5	130
Zinc	μg/L	EPA 200.7	29	20	58
Total VOCs	μg/L	EPA 601 & 602	e	e	5
Benzene	μg/L	EPA 524.2	No analysis	No analysis	0.7
Perchloroethylene	μg/L	EPA 524.2	<0.5	<0.5	4
Vinyl chloride	μg/L	EPA 524.2	<0.5	<0.5	2
Base neutral/Acids and pesticides	μg/L	EPA 625	e	e	5

Table D-2. (Continued)

Analyte	Units	Method	Date/analytical results		Discharge limit[a]
			15 Nov 94	14 Dec 94[f]	
Total petroleum hydrocarbons	μg/L	EPA 8015	<50	<50	50
Polynuclear aromatic hydrocarbons	μg/L	EPA 610	e	e	15
Ethylene dibromide	μg/L	EPA 504	<0.01	<0.02	0.02
Total organic carbon	mg/L	EPA 415.1	6.6	8	None
Gross alpha	pCi/L		<0.95	f	15[c]
Gross beta	pCi/L		2.99	f	50[c]
Tritium	pCi/L		57.9	444	20,000[c]
Fish toxicity	% survival	EPA 600/4-5/013	90	No analysis	90

Notes:

Italic text denotes concentration limits outside of Management Plan Action Levels.

a Discharge Limits as specified in NPDES Permit No. CA0029289.

b Sample not required in this sampling period.

c Water Quality Objectives for Municipal Supply Waters, Table III-2 from the Water Quality Control Plan, S.F. Bay Basin RWQCB, Dec. 1991.

d Laboratory's Reporting Limit could not meet Action Level.

e All compounds in this group are less than the detection limit.

f Analytical data pending, results will be reported in first quarter 95.

Table D-3. Analytical results from DRB discharge point WPDC, September through December 1994.

Analyte	Units	Method	Date/analytical results 15 Nov 94	Date/analytical results 14 Dec 94	Discharge limit[a]
Conductivity	µmhos/cm	EPA 120.1	190	180	900[c]
pH	units	EPA 150.1	8.3	7.3	> 9.0, < 6.0
Total Suspended Solids	mg/L	EPA 160.2	420	600	None
Antimony	µg/L	EPA 200.7	<5	<5	1460
Arsenic	µg/L	EPA 206.2	6.7	9	20
Beryllium	µg/L	EPA 200.7	0.66	*1.4*	0.7
Boron	µg/L	EPA 200.7	230	110	500
Cadmium	µg/L	EPA 200.7	<0.5	<0.5	5
Chromium, total	µg/L	EPA 200.7	44	47	50
Chromium, +6	µg/L	EPA 7196	<10	<10	11
Copper	µg/L	EPA 220.2	*34*	*33*	20
Iron	µg/L	EPA 236.2	No analysis	No analysis	3000
Lead	µg/L	EPA 200.7	*10*	*19*	2
Manganese	µg/L	EPA 243.2	No analysis	No analysis	500
Mercury	µg/L	EPA 245.2	<0.2	<0.2	1
Nickel	µg/L	EPA 200.7	*40*	*44*	7.1
Selenium	µg/L	EPA 270.2	<2	<2	100
Silver	µg/L	EPA 200.7	<0.5	<0.5	2.3
Thallium	µg/L	EPA 200.7	<5	<5	130
Zinc	µg/L	EPA 200.7	*160*	*200*	58
Total VOCs	µg/L	EPA 601 & 602	e	e	5
Benzene	µg/L	EPA 524.2	No analysis	No analysis	0.7
Perchloroethylene	µg/L	EPA 524.2	<0.5	<0.5	4
Vinyl chloride	µg/L	EPA 524.2	<0.5	<0.5	2
Base/neutral/acid extractables and pesticides	µg/L	EPA 625	e	e	5

Table D-3. (Continued)

Analyte	Units	Method	Date/analytical results 15 Nov 94	14 Dec 94	Discharge limit[a]
Total petroleum hydrocarbons	µg/L	EPA 8015	<50	<50	50
Polynuclear aromatic hydrocarbons	µg/L	EPA 610	e	e	15
Ethylene dibromide	µg/L	EPA 504	<0.01	<0.02	0.02
Total organic carbon	mg/L	EPA 415.1	7.1	6	None
Gross alpha	pCi/L		8.21	f	15[c]
Gross beta	pCi/L		11.6	f	50[c]
Tritium	pCi/L		111	225	20,000[c]
Fish toxicity	% survival	EPA 600/4-5/013	90	b	90

Notes:

Italic text denotes concentration limits outside of Management Plan Action Levels

a Discharge limits as specified in NPDES Permit No. CA0029289.

b Sample not required in this sampling period.

c Water Quality Objectives for Municipal Supply Waters, Table III-2 from the Water Quality Control Plan, S.F. Bay Basin RWQCB, Dec. 1991.

d Laboratory's Reporting Limit could not meet Action Level.

e All compounds in this group are less than the detection limit.

f Analytical data pending, results will be reported in the first quarter 1995.

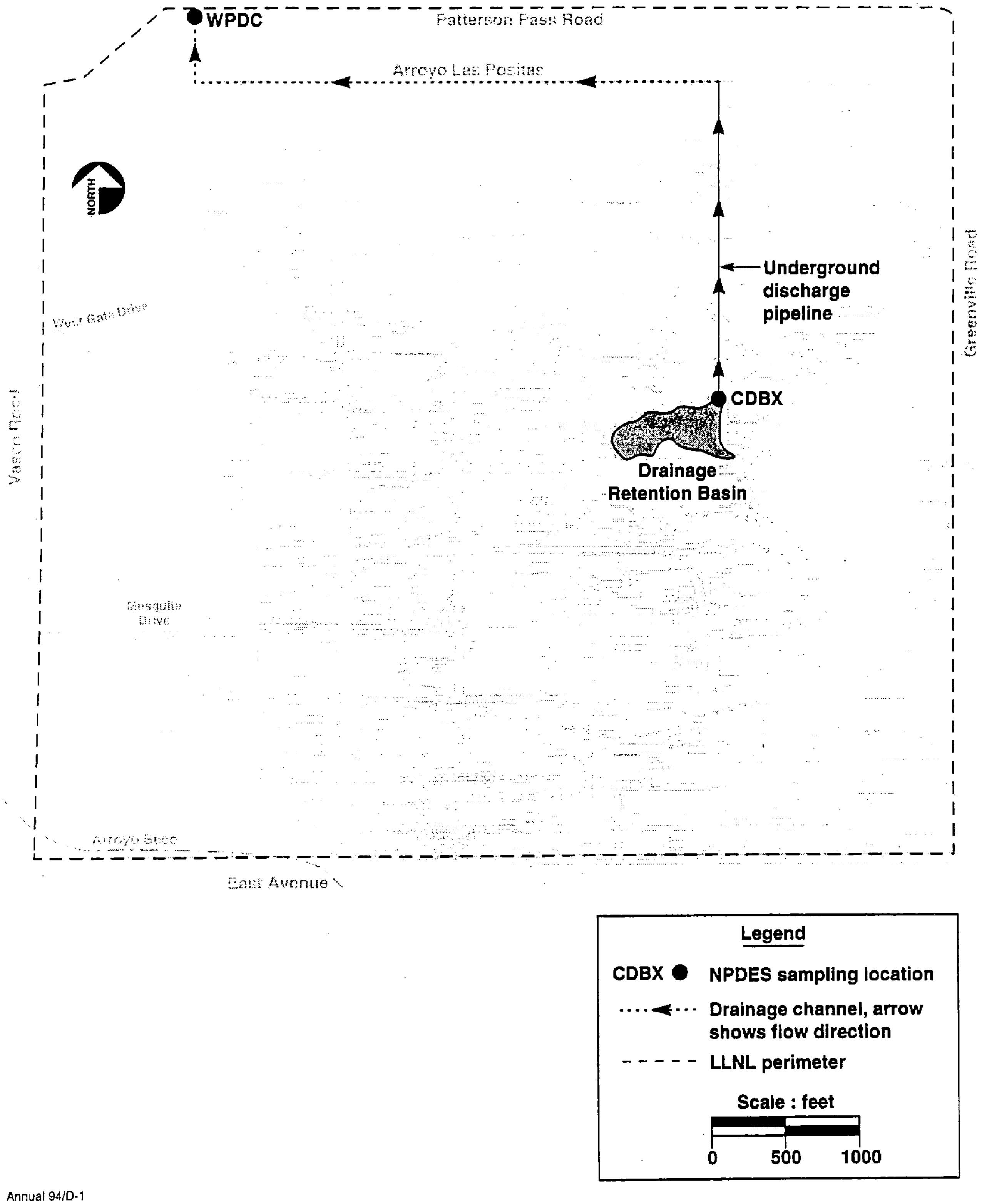


Figure D-1. Location of the Drainage Retention Basin showing National Pollution Discharge Elimination System (NPDES) discharge locations.

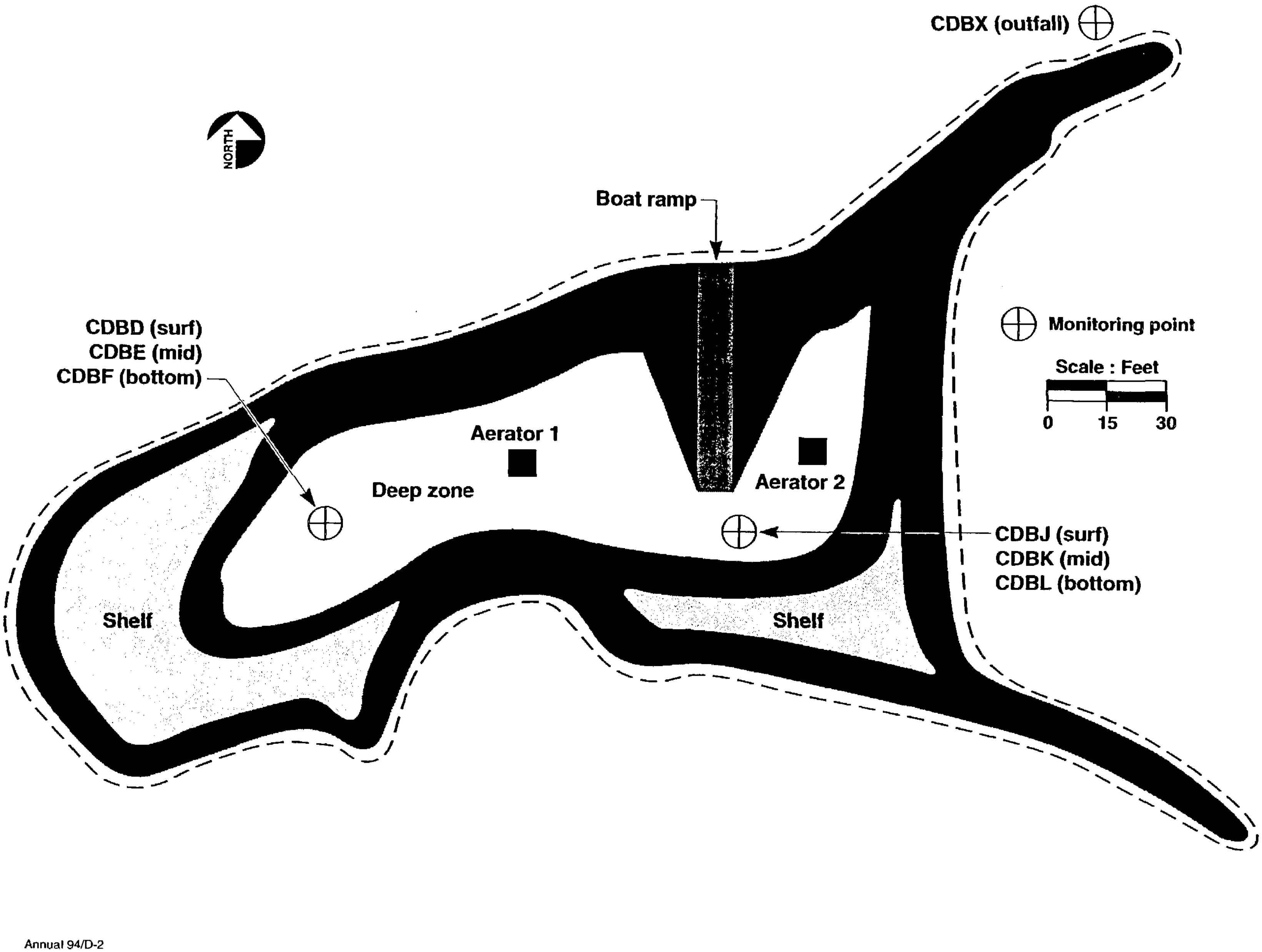
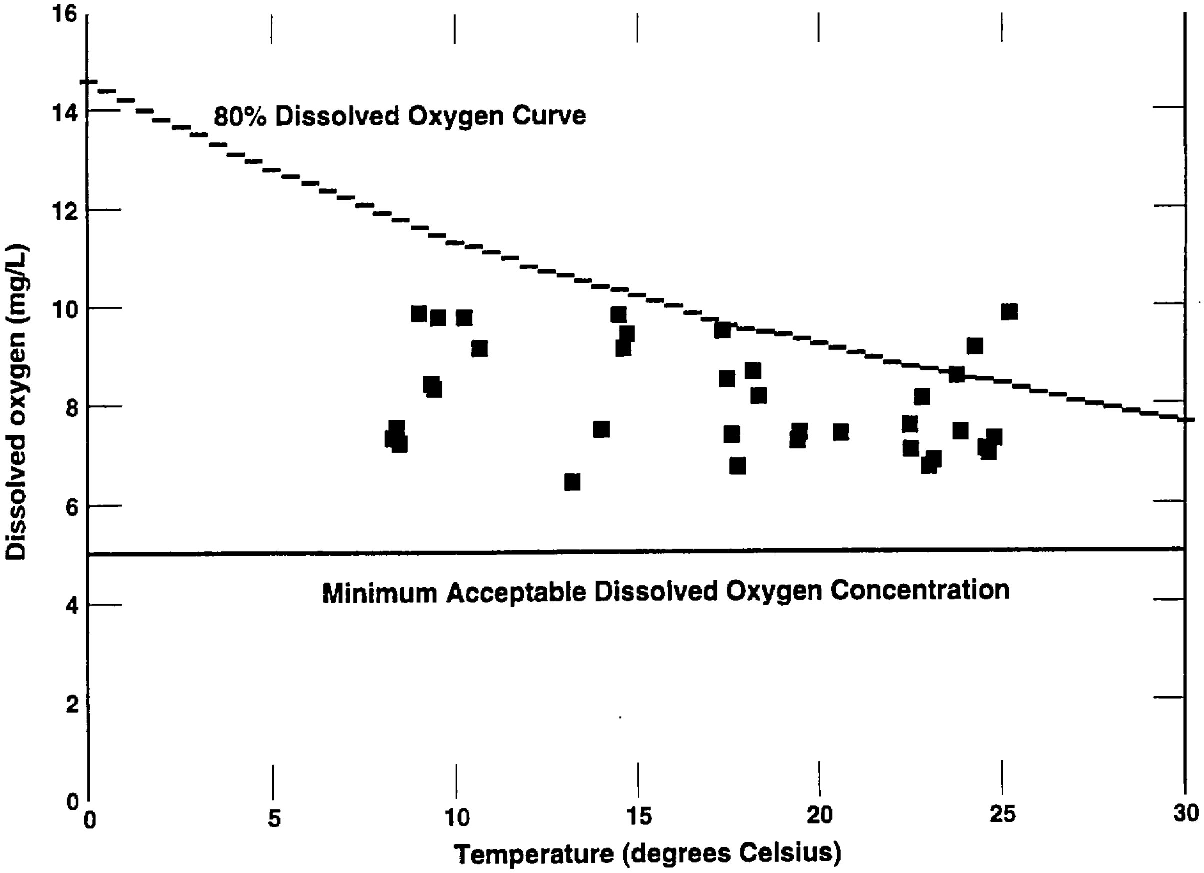
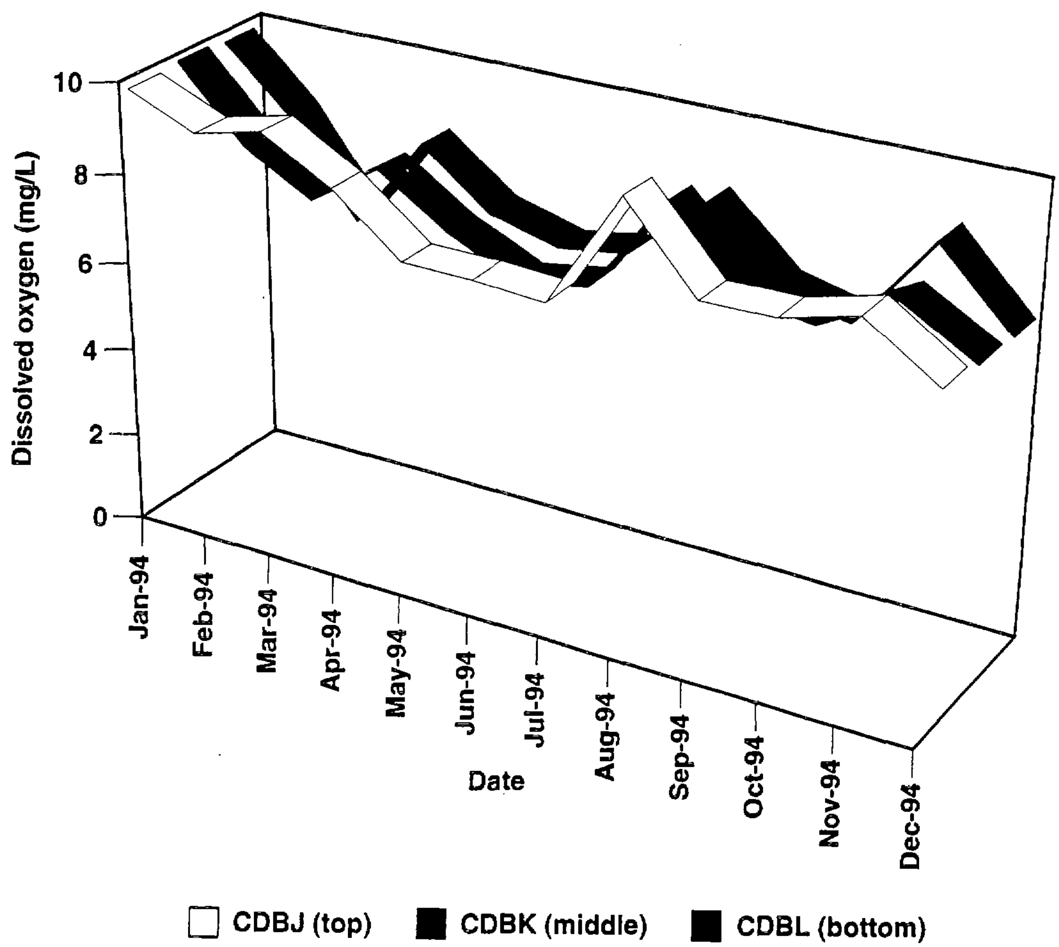


Figure D-2. Monitoring locations in the Drainage Retention Basin.



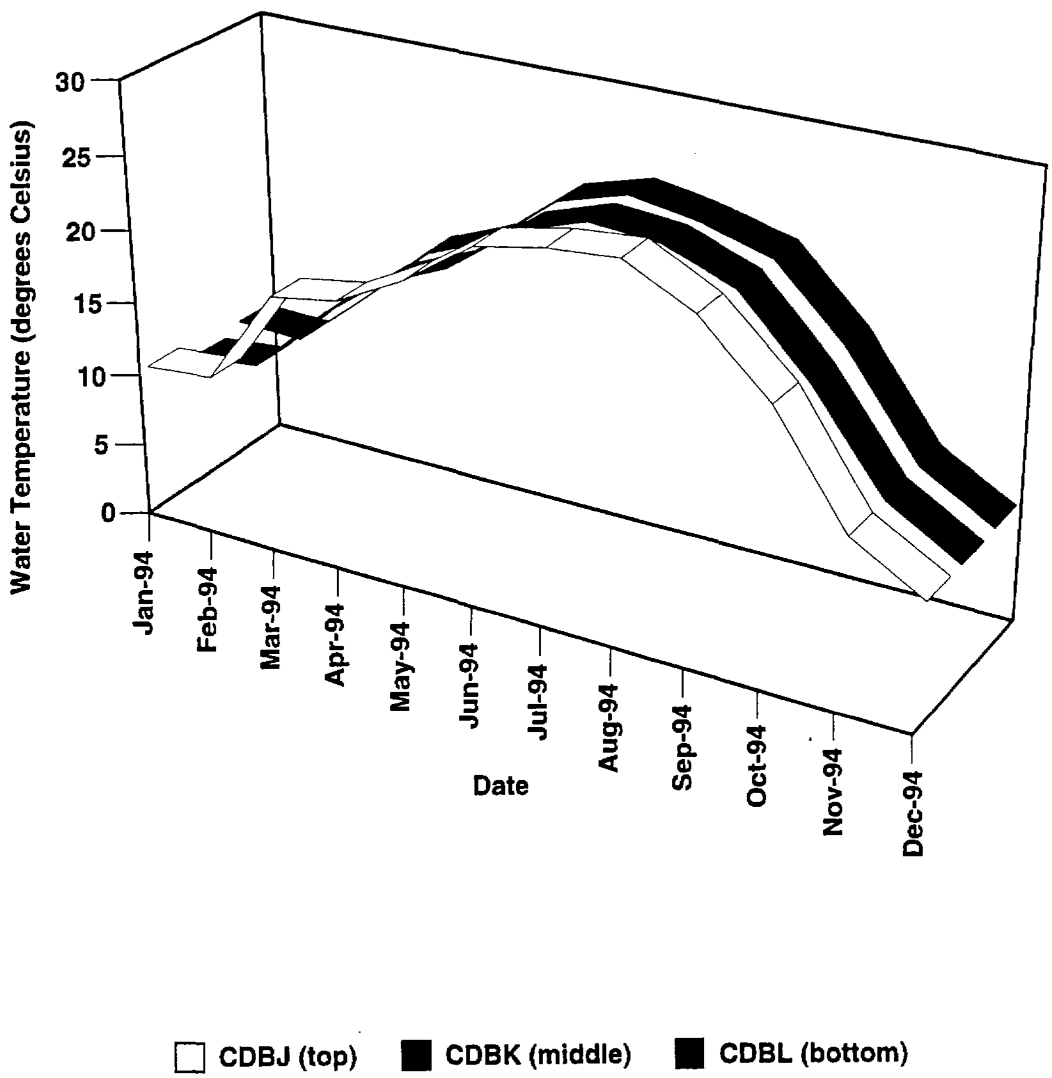
Annual 94/D-3

Figure D-3. Dissolved oxygen vs temperature in the Drainage Retention Basin from January through December 1994.



Annual 94/D-4

Figure D-4. 1994 Dissolved oxygen vs time at three monitoring points within the Drainage Retention Basin.



Annual 94/D-5

Figure D-5 1994 Temperature vs time at three monitoring points within the Drainage Retention Basin.